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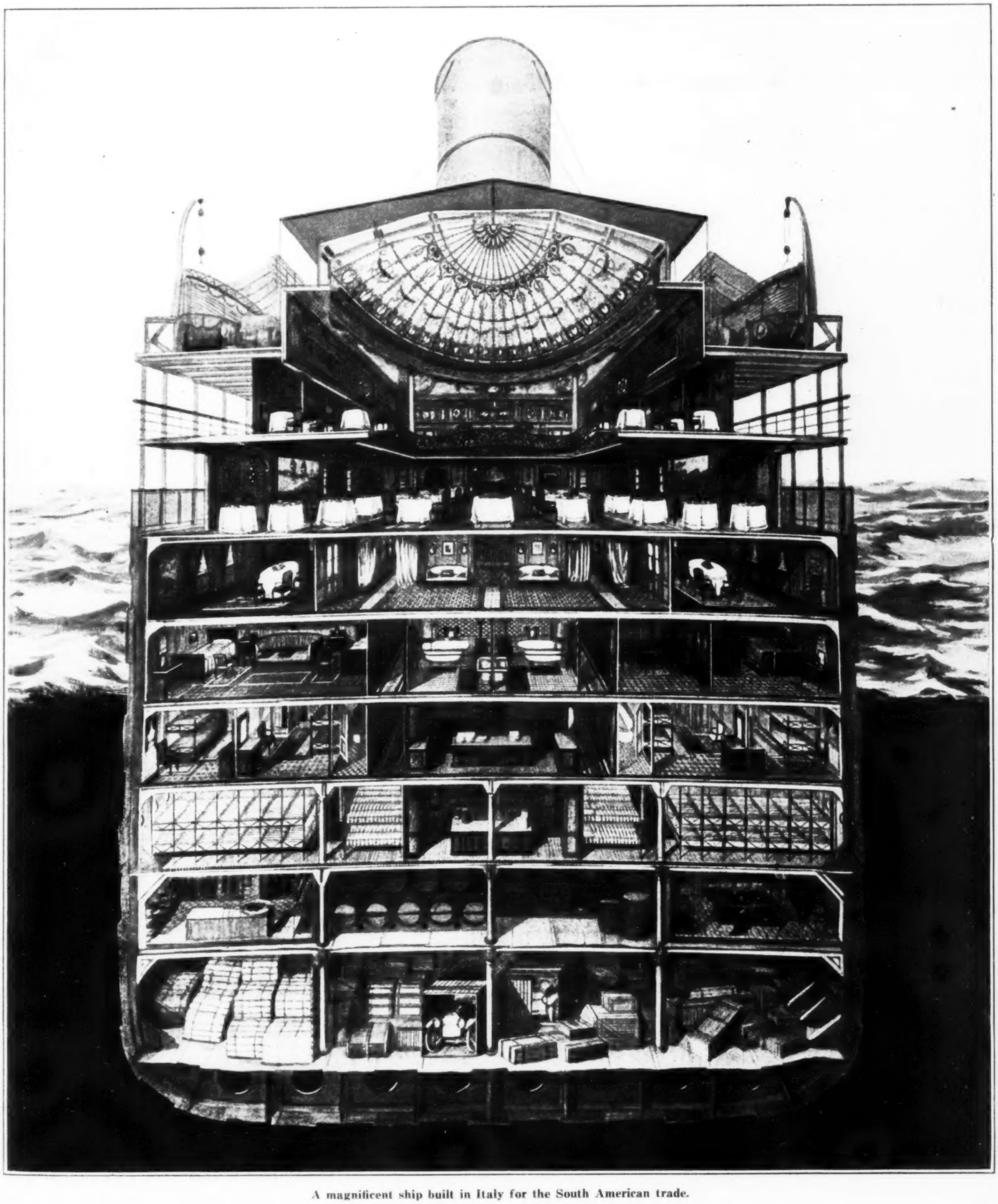


A magnificent ship built in Italy for the South American trade.

THE "DUILIO."—[See page 24.]

# Saving Daylight

## Economic Reasons That Make a Change in Our Hours of Work Desirable

By George Frederick Kuntz, Ph.D., A.M., Sc.D.

CAN we, by taking thought, add an hour to the daylight? Our English cousins, following the lead of the Germans, seem to believe that this desirable end can be attained by legislation. This was originally suggested by Benjamin Franklin in 1784. For many years more or less consecutive efforts have been made in several countries to bring about the enactment of laws providing for a change of official time in the spring and in the autumn. By moving the hands of the clock forward so that the apparent time becomes one, two or three hours faster than the actual time, the average working day would be correspondingly shifted to earlier hours. For example, an eight-hour day, beginning at 8 A. M. and ending at 5 P. M. with the hour's rest from noon to 1 P. M., would really begin, if the hands of the clock were moved forward one hour, at 7 A. M. and would end at 4 P. M., the noonday repose running from 11 A. M. to the actual noon, although according to the clock it would still last from noon to 1 P. M.

This very simple adjustment would produce a number of very beneficial effects. Normally, with the earlier sunrise, we awaken much earlier in the spring and summer than in the autumn and winter, and there would hence be absolutely no hardship in getting up at five or six o'clock, instead of at six or seven o'clock. This being conceded, the worker in any trade or profession, where more or less fixed hours are maintained, would enjoy the inestimable gain of a full hour's daylight and sunshine at the end of the day's labor for recreation, exercise, or repose. This offers marked advantages on the hygienic side.

Scarcely less important, however, and even more so in many cases, is the unquestionable economic gain derivable from the enactment of such a measure. The saving entailed by the substitution of an hour's daylight for an hour during which artificial illumination of some kind must be resorted to, may at first sight seem a small matter, but in the aggregate it represents the saving of a very large sum of money, one running into the millions of dollars for a population like our own.

Perhaps more consistent effort has been made in England, during the past ten years, for the realization of this reform than in any other country. One of the original propositions was to set the clocks forward at three monthly intervals, beginning in the latter part of April, and then to set them back thrice at corresponding intervals from a month after the summer solstice. It was, however, generally recognized that such frequent changes, although they might be theoretically correct, would if put in practice lead to confusion, and also that the extreme change of three hours eventually attained would be rather excessive. Hence the plan was modified to one repeated shift, forward and backward, of one hour in each case. This was the method followed by Mr. Robert Pearce in his Daylight bill, laid before Parliament in 1911. The change was to be effected at 2 A. M. of the third Sunday of April, true mean time being resumed from 2 A. M. on the third Sunday of September. This bill failed to secure the assent of Parliament. The agitation for such a measure was, however, kept up, and in 1914 the Daylight Saving Society introduced a bill along similar lines, but it also failed to pass.

And now, at last, in the throes of the world war and under the economic pressure resulting therefrom, comes the news that Germany, the land of efficiency, has really enacted and enforced the change by effective provisions. Dr. Harold Jacoby, Professor of Astronomy, Columbia University, after remarking that the change in Germany has been made principally for factory workers, confesses that it is not easy to determine whether the main object was to give them more daylight for rest and recreation, or to get better results from the munition factories.

A very ill-considered objection has been made to the systematic introduction of this reform into our own country, by those who in their sincere devotion to individualism are inclined to forget that the great mass of the people require, and indeed welcome, a little official guidance in certain directions. True it is that if you or I wish to change our clocks and watches there is no law to prevent our so doing, just as there is no law to prevent our rising as early as we please in summer, whatever hour our clocks may mark. But in practice we would find all our engagements and all our arrangements during the day in "most admired disorder" unless others were induced to do the same. Thus it is that any change of this kind, to be really of practical worth, must be general, and such general change can only be realized quickly by means of official action. Once this official machinery has been set in motion throughout a country, individuals, even those disposed to look upon the change with a degree of disfavor, will find it to their interest to conform to the new order of things, and will almost certainly be converted into advocates of it when they shall have experienced its benefits.

Germany's measure became operative on the first of May of this year, and Austria-Hungary has already, or will soon, fall into line with her ally. The close commercial connection between Holland and Germany rendered Dutch co-operation almost inevitable, and in the neighboring Scandinavian countries, similar action will soon be taken. The Danish Minister of Instruction has introduced in the Folkething a daylight-saving bill on the lines of the German regulation, making the change effective from May 15th to September 30th; and Sweden and Norway have decided to follow the same course. Nova Scotia has the honor of being the first country in the New World to introduce this innovation.

In all these cases, except the last-named one, we may see an attempt on the part of smaller nations to adjust themselves to the rules obtaining in the territory of a powerful neighbor with whom they are in more or less close touch; but the most important extension of the daylight-saving movement concerns Germany's great rival, England. Here a daylight-saving bill has passed its third reading this week in the House of Commons and its final acceptance is practically assured. The Stock Exchange Committee, which formerly opposed any measure of this kind, has now withdrawn its opposition, and is ready to make the slight rearrangements necessary to keep in touch with the New York Stock Exchange. The London stock market closes now just about the time the New York market opens; should the new hours be applied there would be an interval of about an hour between the respective closing and opening. Not improbably this would prove an entering wedge over here, should our Stock Exchange consider it advisable to conform to the English example.

Of course everything has its price, and where so much is to be gained we must not grudge some little unavoidable inconveniences at the beginning and end of the long-day season. Whatever may be the "suggestive" effect of the clock upon our habits, there can be little doubt that with most persons who lead regular lives, the hours of going to sleep and awakening are automatically fixed and cannot be changed in a day or two, nor does it follow that retiring an hour earlier will make us go to sleep an hour earlier than usual, for in many cases sleep would not ensue until the accustomed hour. However, in a week's time or so, the human machine would adjust itself, with many persons, indeed, sooner than this. The railroad schedules offer, perhaps, the only serious problem of adjustment, as at the very beginning of the new dispensation there would be an overlapping of trains. This would have to be carefully provided for at each of the time-shifts, in the spring and in the autumn. The perfectly satisfactory provisions now in operation in regard to the various time-zones with their differences of an hour, show that this difficulty could be easily overcome.

The Germans, with their habitual foresight, have already warned those undertakings which may be tempted to nullify the provisions of the new law by changing the nominal times of opening and closing, so as to keep up the old rules, that energetic measures will be taken against any such effort to evade the law while apparently observing it, and whatever our opinion may be of the ethical value of German conduct at the present time, there can be no doubt of the power and will displayed by that nation in carrying out any policy which it adopts.

It is to be hoped that here also similar action will be taken, so that full advantage may be had of God's great gift of daylight and sunshine. The more perfectly we bring our habits and lives into harmony with the eternal laws of nature, the greater will be our gain in health, strength and wealth, and all of these are essential to the fulfillment of the great task of the present moment, the attainment of adequate preparedness for all eventualities.

Although this may seem a rather childish expedient, it is an exceedingly practical one, and does not differ essentially from the rule now observed as to railroad time, where, to insure uniformity within a wide territory, clocks and watches are so adjusted that they are either faster or slower than the real time in all but a narrow strip of a given time-zone. Therefore, when a traveler crosses the boundary separating one of these zones from another, he sets his watch an hour faster or slower as the case may be. An equally abrupt and recurrent change of time is carried out on shipboard, when the hands of the ships' clocks (except the chronometer) are moved forward or backward from a half-hour to one hour each day, according to the speed of a ship sailing east or west. When we consider how easily in this case we fall into the habit of readjusting our watches each day to the new time, we can appreciate how simple it would be to make only two changes in the course of a year.

Naturally the advantages of this proposed arrangement are somewhat more obvious in England than with us in the United States, since the days are considerably longer in summer in the British Isles than in any part of the United States. Still, even with us, in New York city, the day is about six hours longer in summer than in winter, giving us about fifteen hours of daylight on the 21st of December, so that we would also benefit by the proposed change of time. Indeed, the expedient of setting the hands of the clock backward or forward to change the apparent time, is already resorted to in many mines, to adjust the hours of work to the changes of season.

Some years ago, in anticipation of the passage by the British Parliament of a bill regulating the course to be pursued in this matter, a practical application of the principle was made in the General Post Office in London. The Postmaster-General, Mr. Sydney Buxton, asked of the officials whether they would prefer to change their hours of work, then lasting from 10 A. M. to 4 P. M., by substituting the hours from 9 A. M. to 3 P. M., or whether they would prefer to leave the former hours unchanged. A very large majority favored the change, and the new arrangement was accordingly adopted. In this way the objects of the proposed legislation were attained without laying violent hands upon the clock. However, any attempt to carry out the plan on a large scale by such means would almost certainly encounter great difficulties, for while the directors of some institutions or business enterprises might favor the adoption of the new method, others would cling to the old usage, and great confusion would necessarily result. All the activities of our modern life are so interdependent that any such radical change could only be desirable if made general by legislative enactment.

At a meeting held in the Guildhall in London, at which the Lord Mayor presided, one of the speakers referred to the great variety of "times" we already possess: mean time, apparent time, local time, sidereal time, etc. Alluding to the fact that when it was Wednesday on one side of the meridian 180 degrees, it was Tuesday on the other side, the speaker remarked humorously: "I can imagine a Chunchus at the Behring Sea smoking his pipe with one foot in Tuesday and one in Wednesday."

Although it must be confessed that the *Westminster Gazette* is right enough in its description of the Daylight-Saving Bill as an illustration of the childish pastime of "let's pretend," we must not forget that people are more easily moved by an appeal to the imagination than by purely rational considerations. Napoleon, a past master in the art of influencing men, said that imagination ruled the world.

Little notice has been taken of the fact that this "new idea" was present to the mind of Benjamin Franklin, who, while in Paris, wrote an article on this subject in French, which was published in the *Journal de Paris* of April 26th, 1784. The English version appears among Franklin's essays under the title: "An economical project."[1] The tone of the paper is semi-humorous but the writer is evidently quite in earnest as to the essential advantages of his plan. He relates that retiring to rest one morning at about four o'clock something awakened him suddenly about two hours later, and he was surprised to find his room flooded with sunlight. He continues:

"This event has given rise in my mind to several

[1] Life and Writings of Benjamin Franklin; Essays, New York, 1834, pp. 163-167.

serious and important reflections. I considered that, if I had not been awakened as early in the morning I should have slept six hours longer by the light of the sun, and in exchange have lived six hours the following night by candlelight; my love of economy induced me to muster up what little arithmetic I was master of and to make some calculations."

Franklin estimates that there were (in 1784) 100,000 families in Paris, and that each of these consumed half a pound of "bougies" or candles per hour. Pursuing his reckoning, he finds that very late risers waste in the summer season seven hours of sunlight per day and substitute seven hours of candlelight after sundown. These seven hours multiplied by 183, the number of days from the 20th of March to the 20th of September, gives 1,281 hours of life by candlelight, or 128,100,000 hours for the 100,000 families. If a half pound of wax or tallow was needed for an hour's lighting, and the material cost thirty sous per pound, then the total expense would be no less than 96,075,000 francs (about $19,000,000), "an immense sum! that the city of Paris might save every year by the economy of using sunshine instead of candles."

Turning to the means for insuring compliance with the new system, Franklin proposed that a tax of a franc should be laid upon every window found closed when the sun was shining; that no family should be supplied with more than one pound of candles per week; that no coaches, except those of physicians, surgeons or midwives, should be allowed on the streets after sundown. Lastly every morning at sunrise all the church bells should ring, "and if this is not sufficient, let cannon be fired in every street to wake the sluggards effectively and make them open their eyes to see their true interest."

These somewhat whimsical expedients were, of course, not seriously proposed, but there is little question that Franklin was quite right when he wrote: "All the difficulty would be in the first two or three days; after which the reformation will be as natural and easy as the present irregularity; for *ce n'est que le premier pas qui coûte*. Oblige a man to rise at four in the morning and it is more than probable he shall go willingly to bed at eight in the evening; and having had eight hours of sleep, he will rise more willingly at four the following morning."

Also Franklin's estimate of the saving involved is purposely exaggerated. Few people now-a-days, and but few in the Paris of 1784, except some of the lazier nobility, could be said to rise at noon, or nearly noon, so that a saving of seven hours' daylight would have been possible, even during the longest days. Moreover, an hour's use of a single light costs far less than 15 cents now, whatever it may possibly have cost then. As to the real prospective saving at present, we have an estimate for England by Sir Henry Norman, who puts the amount at $12,500,000 annually. Certainly, with more than double the population of England, the saving in the United States should be at least $25,000,000, enough, if judiciously expended, to pay for a couple of super-dreadnoughts.

An important consideration in regard to the expense of lighting is the fact that but little productive work is done by artificial light, which is chiefly used by those who seek for recreation or dissipation. Hence almost all the money expended for this purpose brings in no return. In view of this it might even be advisable to move the hands of the clock forward two hours instead of one hour; this would be quite practicable, and the gain in daylight, as well as the saving of artificial light, would be so much the greater.

Prof. Harold Jacoby has taken great interest in the proposed change to time, but he does not think this change would be productive of the same advantages here as in Great Britain. Our territory is so large, extending, as it does, approximately from 24 degrees 30 minutes to 49 degrees North Latitude, and the differences in the time between sunrise and sunset are so considerable in various localities, that he thought it would be very difficult to establish a rule applicable to all parts of the country. Even in England, during the successive attempts in the last few years to pass a Daylight-Saving Bill, considerable opposition to the change developed among the railroad companies, since it entailed a complete readjustment of the schedule, especially if a large number of people should fail to observe the new order of things.

Very possibly, as we have already remarked, most of these difficulties are more apparent than real, and may be disregarded in view of the considerable advantages to be secured. Naturally, the plan would only work well north of latitude 30 degrees (or perhaps 35 degrees) for in southern lands the difference in the length of the day is not sufficient to make a change of time important, and the daylight hours are less desirable in summer because of the high temperature, so that the hours after sundown are the most appreciated.

Until quite recently many of us were unaware that a daylight-saving plan had already been in operation for two years in Cleveland, Ohio. Here, however, the change once made was continued throughout the whole year. The method chosen was very simple, nothing more than making the time of the next time-zone east of the one in which Cleveland is situated the standard for that city. The city ordinance read as follows:

Be it ordained by the Council of the City of Cleveland, State of Ohio:

Section 1. That the standard of time throughout the city of Cleveland shall be that of the seventy-fifth meridian of longitude west from Greenwich, known as "Eastern standard time," municipal offices and legal or official proceedings of the city of Cleveland shall be regulated thereby; and when by ordinance, resolution or action of any municipal officer or body an act must be performed at or within a prescribed time, it shall be so performed according to such standard of time.

Section 2. When a clock or other timepiece is on or upon a public building maintained at the expense of the city of Cleveland, the board, commission, officers or other person having control and charge of such building, shall have such clock or other timepiece set and run according to the standard of time as provided in Section 1 hereof.

Section 3. This ordinance shall take effect from and after the 30th day of April, 1914.

The knowledge of this official action was sufficient to insure conformity among the citizens. On May 1st, 1914, the initial day of the new reckoning, all the Clevelanders moved the hands of their clocks and watches one hour ahead, and the new rule has been in use since then. The good example has been followed by Detroit, Michigan.

One great advantage of this plan is that the time of Cleveland and Detroit is identical with that of a nearby time-zone, a circumstance that favors a corresponding change in other parts of Ohio and Michigan, and may foreshadow the adoption of the new standard by the railroads. It was recognized by the Clevelanders that this action on the part of the railroad officials would not necessarily follow legislation making the change effective through the whole State. A circumstance that makes this Cleveland time-standard especially interesting, is that it covers the whole year, and not only the six months from April or May to October or November. If we consider the matter carefully, in the case of a one-hour change, there is really no valid reason for moving the clocks back after they have once been set forward. A leading argument against the change has been the temporary dislocation of time tables and of individual habits involved therein. Under the rule recently adopted in so many European countries and warmly advocated here, these inconveniences—only temporary, it is true—are to be encountered twice in every year, whereas by the Cleveland plan the adjustment once attained would be continued indefinitely.

While unquestionably the need for, and the advantages of the new system are distinctly more apparent in spring and summer, the daylight-saving for workers would continue through the greater part of the year. Even on the shortest day, December 22nd, the interval between sunrise and sunset in Cleveland is nine hours, the duration of an eight-hour day, with the hour's intermission. Hence, for nearly the whole year there is a good margin for a daylight gain in the latitude of Cleveland, 41 degrees and 31 minutes North, and even more in the greater part of the United States, which lies south of this latitude.

The movement in favor of the new time-standard was started by the Cleveland Chamber of Commerce Committee on Eastern Time, of which Mr. Samuel H. Hall, a merchant of that city, was made chairman. The project was immediately indorsed by the Cleveland Federation of Labor, the Cleveland Amateur Football Association and the Cleveland Amateur Baseball Association. That the managers and devotees of baseball, football and other sports usually carried on during the afternoon, should welcome the change is easy to understand, as it has more than once happened in the autumn season, that a baseball game has been stopped unfinished because of darkness.

A brief recapitulation of the many advantages to be derived from the lengthened daylight will not be out of place here. It will prove a great benefit for the public health, as light is a physical stimulant, just as darkness is a depressive influence. The toiler will gain a full hour for rest or recreation, and besides this one hour of his working day, beween 7 A. M. and 8 A. M., will fall in the cooler part of the day. That children will profit by the change hardly needs to be urged, as during the school-period of the half-year they will have a long afternoon for play, and can go to bed at a proper and normal hour. Farmers, and above all, those who do business in cities and reside in the suburbs, will soon find out how greatly their day is improved, and will never relinquish the privilege when once it has been conferred upon them. The too brief afternoons the tired city worker now has on his return to his suburban home, would be made long enough for real enjoyment. In industrial plants, the measure would produce greater efficiency and greater willingness to work on the part of the operatives. The saving in the cost of illuminating materials has already been treated of at some length, and there can be no question of the gain of health-bringing restful sleep that will be secured by retiring and rising at an earlier hour.

This daylight saving measure is in some sense a modern scientific realization of the marvelous happening reported in ancient Hebrew history (Joshua X. 12-14) when the great national leader Joshua, to gain a longer period of daylight for the smiting of the Amorites at Gibeon, cried out: "Sun, stand thou still upon Gibeon; and thou moon, in the valley of Ajalon!" As convincing proof of the truth of this tale, the author of the book of Joshua asks, "Is not this written in the book of Jasher?" Perhaps, if there had been clocks in those days, the Hebrew warriors could have been forced to make the daylight period seem longer by setting the hands of their clocks forward a few hours. For the present, the Germans have this advantage, whatever it may be worth, over their gallant French adversaries in the fierce struggle at Verdun, which may mark the climax of the war.

That quite unexpected results may sometimes be produced by legislative measures, is shown by the recent statement that, since the provisions of the Daylight-Saving bill have been put in operation in England, there has been an increased consumption of gasoline, instead of a saving as had been confidently expected. The added hour of daylight has been utilized for motoring, and a motor-car is a very active consumer of gasoline. It is believed that the Government will endeavor to correct this state of things by stringent enactments, just as Sunday "joy riding" has been more or less effectively curbed in England.

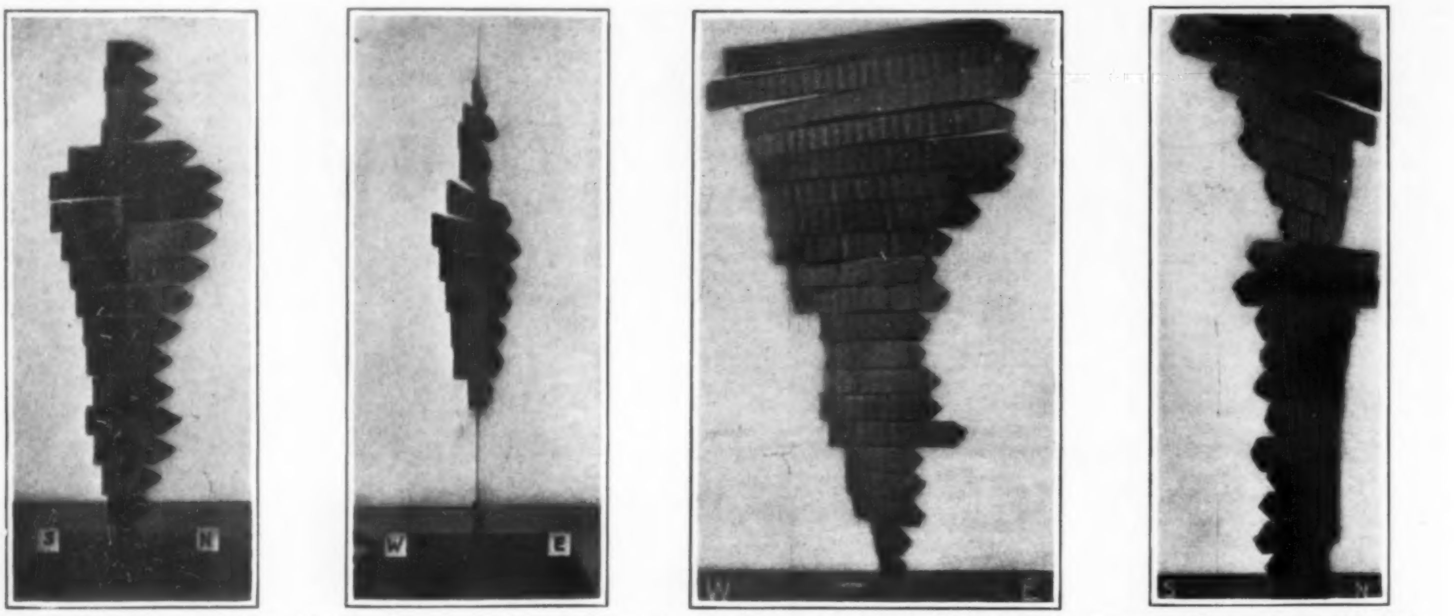
In England, the change was effected at 2 A. M., in the morning of Sunday, May 21st, when all clocks were moved forward one hour, so as to mark 3 A. M. This gave Sunday, a holiday, for adjustment to the new conditions, and 2 A. M. Sunday morning was regarded as the time at which the least interference with railroad trains would result. The return to the old time will be made on September 30th, or rather at 2 A. M. of October 1st, also a Sunday. The only exception to the general rule in public institutions will be in the case of some of the parks in the large cities, which will open at the old time (apparently an hour later), so that the actual time of closing shall not be earlier than under the customary rules, thus giving the public the benefit of their use for a longer time at the end of the day.

Italy fell into line on June 3rd, the new standard being introduced at midnight of that day, when by royal decree all clocks were moved forward one hour. Last, but not least, among the converts to the plan for lengthened daylight was France, where, as we have already noted, there seems to have been a little hesitation to follow a German lead. As, however, England was among the first to conform, and the inconvenience for intercommunication of having a different time-standard in the two neighboring countries must have been patent to all, the new system has now been accepted by the French, the change to go into effect June 14th, and remain in operation until October 1st. Thus we have Daylight-Saving introduced by Germany, England, Norway, Sweden, Denmark, Italy, France and the city of Cleveland, and three of the great Entente Powers, as well as the two Central Empires, are at one as regards a time-stndard. Russia, which still retains the old Julian calendar, and which has no railroad connections with her allies, and but a distant and irregular communication by sea, appears to have less inclination to follow the new fashion.

This subject was presented by the writer on May 19th, 1916, to the Joint Conference Committee of the Engineering Societies. There not being a quorum of this committee present, it was ordered that copies of the address be sent to the representatives of each of the societies for consideration before the next meeting.

## Sawing Cast Iron

At a recent meeting of foundrymen in Kassel a Düsseldorf engineer made an interesting communication on the subject of cutting cast iron with a common carpenter's saw. This can be readily done if the iron be heated. An exhibit was made o. a cast iron wheelbox about 60 millimeters in diameter which had been sawed smoothly in two while in a heated condition in about 1½ minutes by an ordinary joiner's saw. Another engineer present stated that according to his historical studies this method of cutting iron was formerly frequently employed, though now fallen into almost entire disuse.—*Elektrotechnische Zeitschrift.*




* Figs. 1 and 2 represent the conditions at Ditcham, Hampshire, England, on October 1st, 1908; Figs. 3 and 4, the condititions at Blue Hill Observatory, Mass., on August 12th, 1910. Each model is shown from two sides (Figs. 1 and 4 from the east, and Figs. 2 and 3 from the south), so that the orientation of the arrows may be seen. The arrows fly with the wind; the length indicates the velocity at that level. In Figs. 1 and 2 each arrow represents an air stratum of 1,000 meters and in Figs. 3 and 4 of 500 meters.

Figs. 1 and 2 are taken from Cave's "The Structure of the Atmosphere in Clear Weather," 1912. Figs. 3 and 4 are from models based on soundings made at Blue Hill Observatory.

**Figs. 1 to 4.—Models representing vertical wind distribution.**

# Aerography*

## The Science of the Structure of the Atmosphere

By Alexander McAdie, Harvard University

Except in its relation to aëronautics, few people appreciate the significance of upper-air exploration. It is much more than the getting of high-level temperatures, interesting as these may be. It is the prospect of a wider knowledge of the aërial ocean which lures the meteorologist. Until this work be accomplished, a man looking up at the clouds and with a map giving only surface conditions, can know no more about the sea of air above him than primitive man knew of the sea of water when he first ventured upon it. Small wonder that meteorology has made such slow progress in forty years; no wonder that weather maps seemingly alike should be followed by different conditions.

The term *aërography* is new, making its initial appearance perhaps with this article. Its meaning remains to be given; and at present we can hardly hope to do this so fully and completely that later modification will not be necessary. Like its analogues ***geography*** and ***hydrography***, aërography, taken literally, means a description of the air. In the past four or five years the term aërology has been used in connection with the exploration of the upper or so-called free air; but it would seem more appropriate to let this term embrace the whole domain of atmospherics, while the word aërography might well be restricted to a description of the atmosphere at various levels. The flow and counter-flow of the air, the pressures, temperatures, humidities, dust content, electrical charge, etc., would thus be proper subjects for consideration under aërography, as well as their functions and relation to life; but such broader questions as the evolution of the atmosphere, its relation to the planet and to planetary phenomena, would be appropriately discussed under aërology.

Through the initiative of two non-official aërographers, the late Teisserenc de Bort and the late A. Lawrence Rotch, it has recently been established that the atmosphere is not of a homogeneous and uniform character but consists of two great divisions, a lower region, where temperature falls with elevation, and an upper region (in general higher than nine kilometers), where the temperature increases with elevation. The latter has been called the isothermal region, but such a name is rather misleading and should be discontinued in favor of Teisserenc de Bort's term ***stratosphere***. The lower portion may appropriately be called the ***troposphere***.

Pioneer but none the less excellent aërographies are "Charts of the Atmosphere for Aëronauts and Aviators," by A. Lawrence Rotch and Andrew H. Palmer, published in 1911,[1] and the "Structure of the Atmosphere in Clear Weather," by C. J. P. Cave, 1912.[2] The introduction to the first-named volume is so brief and tells its story in such a straightforward way that we may well quote it entirely. Professor Rotch says:

"Although the exploration of the air, which was begun twenty years ago in France and Germany and at Blue Hill, was undertaken for the elucidation of meteorological problems, yet much of the data obtained is of importance for the new art of aërial navigation. Accordingly, some of the information which has been gathered by the Blue Hill Observatory in the United States and on the Atlantic Ocean through co-operation with a similar French institution, is here presented in a practical form for aëronauts and aviators. The term aëronaut is used to designate the pilot of a balloon, while aviator is restricted to the pilot of a flying-machine heavier than air.

"Thus the work which Lieutenant Maury did fifty years ago for the surface winds and ocean currents is now extended into the overlying ocean of air. This is the more necessary, since the whole aërial ocean is subject to stronger commotions than even the surface of the aqueous ocean and is navigable throughout a depth equal to that of the latter.

"The following charts, which are believed to be the first of the kind adapted to the use of airmen, relate only to portions of the United States and the Atlantic Ocean, but they will doubtless be perfected by aërologists and extended in the near future to other parts of the globe."

Cave's book is essentially an investigation of the wind currents in the light of the results obtained by sounding-balloon work in Great Britain. Certain structural types are recognized and considered in their relation to the surface wind, the gradient wind, and the general pressure and temperature distribution. The strongest air motion or wind is found just below the stratosphere; and it would seem that pressure changes originate in this region and probably control conditions throughout the lower atmosphere. We may note here the somewhat startling suggestion of Dr. W. N. Shaw[3] that wind variations may better be referred to this upper level than to the surface. Cave is of the opinion that such a base simplifies the problem. For example, working downward, he finds[4] that in a certain ascent (Sept. 15th, 1911) the west-east component of air flow decreased from +32 m/s. (meters per second) at a height of 9 kilometers to —8 m/s. at 1 kilometer. This means that the *flow was reversed with approach to the earth's surface*. Similarly the north-south component decreased from +12 m/s. to —10 m/s.

Aërographers, then, may well begin their work with these two volumes by Rotch and Cave. If the titles sound somewhat strange to our ears let us recall the quaint expression used by the Dorset squire, Robert Boyle, in his book published in 1660, entitled "The Spring of Air." This volume undoubtedly marks the beginning of positive knowledge regarding the physical processes of the atmosphere, for, crucial as were the experiments of Torricelli, Pascal, and von Guericke, it was Boyle who showed us that the air was elastic; and his law of pressure and volume relation, expanded later into the characteristic equation of a pure gas, lies at the bottom of our modern thermodynamics.

We shall appropriate the term "structure" from Cave, for aërography must be, in essence, a description of the structure, or make-up, of the atmosphere. But every structure must rest upon a base; and in aërography it may be necessary to discard the old sea-level plane so familiar to us, but now known to be of somewhat doubtful value, when atmospheric conditions over continental areas are to be reduced downward. How can we get another base plane? It may be remarked at this point that it is a difficult matter to adequately represent atmospheric conditions on a flat map. The daily weather map in its present form—and there has been practically no change in forty years—by no means represents conditions at the bottom of the ocean of air; and perhaps much of the uncertainty of forecasting may be traced to faulty graphics. Again, the aërographer must be able to show on the base not only pressure and temperature gradients, but water-vapor content and, for lack of a better name, dust load, meaning thereby small and large nuclei of condensation, ions, and electrons. And it will be a great step forward when these can be shown for all levels. Then, as a geographer would chart continents, coasts, and islands, the aërographer would chart hyperbars and infrabars—regions of excessive air flow and regions of no flow or stagnation—also levels where the interchange of air was mainly by "advection," or horizontal motion, and where the interchange was by "convection," or vertical motion, using terms introduced by Ernest Gold in his prize essay on "The International Kite and Balloon Ascents."[5]

With such a base map and such auxiliary charts the winds and clouds will take on a new significance and can be studied to advantage. The layman as well as the expert would be able to follow the general circulation, and follow intelligently the average west-to-east drift around one pole and the reversal at the other.

*From the *Geographical Review*.

[1]24 full-page charts, with descriptions. John Wiley & Sons, New York, 1911. (Review in *Bull. Amer. Geogr. Soc.*, vol. xliv, 1912, pp. 861-862.)

[2]XII and 144 pp. University Press, Cambridge, 1912. (Review in *Bull. Amer. Geogr. Soc.*, vol. xlv., 1913, p. 62.)

[3]*Quart. Journ. Royal Meteorol. Soc.*, vol. xxxviii., 1912, pp. 46-48, and *Nature*, vol. lxxxviii., 1911-1912, p. 141.

[4]*Op. cit.*, p. 10.

[5]*Geographical Memoirs No. 5* (=pp. 61-144) Meteorological Office, London, 1913. Reference on p. 109.

interruptions and displacements of the great air streams could be correlated with abnormal weather conditions and give us firmer ground in forecasting. At present one must applaud rather the valor of the forecaster than the value of the forecast. Such charts would go far in settling discussions regarding the origin of cyclones and anti-cyclones, discussions which, so long as they are based upon present charts of air flow, must continue to be unsatisfying.

Returning again to the apparent structure of the atmosphere: as indicated by the models used by Cave, it would seem to be entirely feasible to show the sequence of wind velocities and directions at various levels appropriate to certain types of weather and certain seasonal conditions. Let us also consider Shaw's suggestion of the stratosphere as the principal plane of reference. It may seem strange to attempt to use so variable a level as the base of the stratosphere, yet it may be after all most appropriate, since the atmosphere is itself variable and mobile. The geographer deals with a solid earth, and there is no flow horizontally or vertically. True, we live upon a rotating geoid; but our sensations and impressions are such as would be common to dwellers upon a flat surface. We are handicapped in comprehending air motion because all our experiences are based upon impressions of level and fixed planes. We are, for example, absolutely unconscious of any deflective effect of a moving air current due to the earth's rotation.

It is a peculiar fact about the stratosphere and one full of significance that it does not remain at a fixed height but varies with season and latitude. At the equator, as we rise in air, the temperature continues to fall to a much greater height than in temperature latitudes. Indeed the lowest temperature, probably the lowest natural temperature, is found above the equator. This state of affairs was anticipated by Teisserenc de Bort and Rotch and has now been proven by certain ascensions. Thus at Batavia, Java, on December 4th, 1913, the sounding balloon reached a height of 26 kilometers, entering the stratosphere at 17 kilometers and recording a temperature of 192 degrees *A* (—112 deg. Fahr.). In other words, the stratosphere is highest over the equator and lowest over the poles, so far as we know.

Expression of air flow, then, is the first desideratum in aërography. The aërographer, however, is at present in something of the quandary in which a geographer would be who depended upon a scale of distance that could be applied only in one direction. A map based on such co-ordinates is, of course, of limited value, and this is true in aërography if we measure only horizontal and not inclined and vertical flow.

Investigators have been singularly slow in measuring and expressing air flow. Records of horizontal flow date back to the middle of the seventeenth century, or rather began about that time in Italy; but the measurement of vertical flow is still wanting, although W. H. Dines emphasized the need in 1887 and gave us a new form of anemometer. The whole series of wind measurements made in various official weather services throw little light on the vertical movement of the air. And what is still more disheartening, there is a very large error in the horizontal velocities as published.

It is of the utmost importance that we know something or have some way of representing the vertical component of motion of the air. The formation of rain, local and general air drainage, pressure gradients, and temperature gradients are affected by the duration and strength of ascensional and descensional currents. In aëronautics, too, this matter is important. In a recent paper[6] we find the conclusion that on cloudless days the average upward velocity at the given point was about 0.5 meter per second, while on days with detached cumulus clouds the average velocity was about 2 meters per second.

But the running of the air—to translate literally the old Greek definition of wind—is not a steady, uniform, and continuous motion. On the contrary the flow is frequently of an intermittent character. There are lulls and gusts; and there are eddies and vortices, small and large. This unevenness of flow was brought out clearly by Professor S. P. Langley in his paper on "The Internal Work of the Wind."[7] In the light of present achievements in aviation it is interesting to read his statement, which seemed so fantastic when written, that an indefinite source of power for the maintenance of mechanical flight might lie in this unevenness of flow, which he called the internal work of the wind. And he adds, what is of some importance in aërography, that "the actual effect of the free wind, which is filled with almost infinitely numerous and incessant changes of velocity and direction, must differ widely from that of a uniform wind such as mathematicians and physicists have almost invariably contemplated in their discussions."

In order to illustrate with more detail the structure of the free air as determined by modern soundings, we have borrowed from Cave's book one of the many models shown (Figs. 1 and 2). This represents the wind distribution on October 1st, 1908, seen from the east and from the south. The greatest height in this case was 17.6 kilometers. The diagram (Fig. 5) shows the relation of wind elements to heights.

The structure indicated by Figs. 3 and 4 is that of a typical mid-summer fair-weather day on the New England coast. There was no sea breeze nor even the northeast inflow found frequently under anti-cyclone conditions. The structure is exceedingly uniform. In the lower strata the velocities average from 2 to 6 meters per second, and the flow is fairly steady in direction horizontally. There is a tendency to shift to the north up to about 2,800 kilometers, then an increasing westerly component. The sky was practically without clouds. An extensive high area moving east at a normal rate overlay the eastern half of the United States. In the Ohio Valley and Lake Region the pressure ranged from 1,020 to 1,025 kilobars. The twenty-four hours following were without rain in Ohio, Pennsylvania, New York, and New England. In fact the day was a typical fair day, and the structure may be said to indicate a certain stability and absence of turbulence.

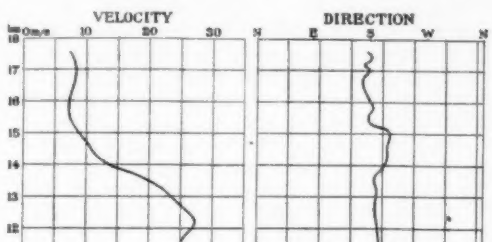



Fig. 5—Diagram showing, for the wind conditions at Ditcham, England, on October 1, 1908, represented by the model of Figures 1 and 2, the relation of velocity and direction to height. Based on a figure in Cave's "The Structure of the Atmosphere in Clear Weather," 1912.

The sounding balloon was watched until it burst, and the highest point deduced from the meteorograph trace was used as the highest point for wind observations; up to 4 kilometers the wind observations were deduced from the two-theodolite method; above this the balloon was supposed to have a uniform acceleration up to the highest point reached, and the wind velocities were calculated on the one-theodolite method.

In general the sub-stratosphere is the region of maximum air motion. Again, the modification of wind direction seems to progress downward. Perhaps I can not do better than sum up the impression which such models of structure give than by quoting the words of Dr. W. N. Shaw:[9]

"It appears that we must regard the sub-stratosphere and the regions above, as the dynamical laboratory of the atmosphere, where the main causes of pressure changes originate, and the troposphere beneath the sub-stratosphere as the physical laboratory of the atmosphere, where cloud, rainfall, and other physical phenomena are produced by local causes, induced, in some cases, by the effect of the dynamical changes in the upper regions."

Thus far we have laid stress on the flow of the air. But temperature and other data are also available. Thus W. H. Dines[10] has given us the normal isopleths of temperature and also pressure from sea level to a height of 20 kilometers and curves showing the local difference from the mean temperature for each level. The Geophysical Institute of Leipzig, under the direction of V. Bjerknes, is publishing a series of synoptic charts for three-day periods of the year 1910 showing the conditions at different levels.[11] The atmosphere is divided into ten principal isobaric levels. In the last number issued, representing the period August 8, 9, and 10, 1910, the stations furnishing soundings were Trappes near Paris, Uccle near Brussels, Pyrton Hill near London, Crinnan near Glasgow, Oughterard on the west coast of Ireland, Manchester, Pavia, Friedrichshafen on Lake Constance, Strassburg, Hamburg, Lindenberg near Berlin, Vienna, Pavlovsk near Petrograd, Nijni-Oltchedaeff in southwestern Russia, and Munich. There were also auxiliary cloud observing and mountain stations. With the data for these stations we can at once construct over Europe the heights in dynamic meters for each stratum of 100 kilobars and also what may be called the relative topography, i. e. the value in dynamic meters between each successive level, or, in other words, the gradient for the aërographic topographer.

Thus the making of aërographic surveys is already under way. Perhaps the day is not so far distant when charts of air structure will be available for consecutive tri-hourly periods for the use of aviators and aërial engineers, for the time is rapidly approaching when problems of transportation *via* air routes must be considered.

[6]Report on Wind Structure No. 4 (for 1912-1913): Papers by J. S. Dines. Meteorological Office, London, 1914.

[7]*Smithsonian Contributions to Knowledge*, vol. xxvii., No. 2, Washington, 1893. 23 pp.

[8]Langley Memoir on Mechanical Flight, *Smithsonian Contributions to Knowledge*, vol. xxvii., No. 3, Washington, 1911. 320 pp. Reference on p. 42.

[9]The Free Atmosphere in the Region of the British Isles: Second Report. By W. H. Dines, with a preface by W. N. Shaw. *Geophysical Memoirs No. 2* (=pp. 11-50), Meteorological Office, London, 1912. Reference on p. 22.

[10]*Op. cit.* sub. 9, p. 29.

[11]Synoptische Darstellungen atmosphrisher Zustände: Jahrgang 1910. *Veröffentl. des Geophys. Inst. der Univ.* Leipzig; Heft 1. Zustand der Atmosphäre über Europa am 6. Januar 1910 (Leipzig, 1913): Heft. 2,—am. 2, 3 und 4 Februar 1910 (Leipzig, 1913; Heft 3—am 18, 19 und 20 Mai 1910 (Leipzig, 1914); Heft 4,—am 8, 9 und 10 August 1910 (Leipzig, 1915).

## Galalith for Insulating Wounded Nerves

One of the most painful results of wounds, as frequently exemplified in the present war, is the embedding of nerves in scar-tissues, so that on healing the patient finds himself unable to use the muscles governed by a motor nerve, or else subject to severe neuritis when a sensatory nerve is thus subjected to pressure. In such cases an operation is often performed to detach the imprisoned nerve. In order to prevent its being again involved, it is either insulated by tubulization or is shielded by having a layer of skin, fat, muscle or connective tissue sewn over it. This latter method is frequently unsuccessful because all such living tissues tend to shrink.

In employing the former method various materials are employed for the insulating tubes. Thus in the Russo-Japanese war preserved and sterilized calves' arteries were used. Other tubes are made of small bones whose mineral matter has been removed, of magnesium, of non-vulcanized rubber, and of gelatine hardened in formalin. The requisites for such tubes in general are ease of sterilization, possibility of being gradually absorbed by the body, the absence of power to irritate the wound as do most foreign bodies, and cheapness, as well as capability of being obtained in the proper length. All these qualities are united, according to Dr. Siegmund Auerbach of Frankfort-am-Main, writing in the *Münchener Medizin Wochenschrift*, in the artificial material Galatt Galalith. This is a patented substance, resembling horn or celluloid, which has been on the market some considerable time, as material for making combs and other toilet articles, cigarette holders, etc. It is prepared from the cheese or casein of milk by treatment with an aqueous solution of formaldehyde.

It may be sterilized by boiling in ordinary water, and the boiling softens it so that it is easy to cut from it tubes of the proper length. Dr. B. Fischer of Frankfort has proved by experiment on animals that it is readily absorbed, and practice has shown that it has no "foreign-body effect" when applied to sterile wounds. *Prometheus*, from which we quote, expresses the belief that it may be useful for other surgical work.

## Migratory Consumptives

*American Medicine*, in commenting on a statement of Passed Assistant Surgeon Lanza in the Public Health Reports, says that for many years physicians have been advising consumptives of all kinds and classes to go out West, where the climate is more conducive to physical welfare, as a simple solution of the problem before them; but it points out that such advice should be discountenanced where the patient lacks adequate financial resources, as no climate alone is sufficient to mitigate the evils attendant on lack of proper food, clothing and shelter, and without which no cure can be hoped for.

The grounds for this opinion are amply apparent in the high death rate by consumption in Colorado, which is accounted for by the large number of such people who migrate to that State without adequate means of support. It is also pointed out that the indigent consumptive can frequently be much better cared for at home, especially in some of the large cities, where the subject is receiving attention.

# Medieval Universities*

## The Revival of Learning in Europe, and Curious Regulations of Discipline

### By Clayton Sedgwick Cooper

To understand the drifts and to secure the point of view of education in the West one must go back to the revival of learning in Europe in the twelfth and thirteenth centuries. There were two distinct sources of this intellectual awakening, one the influence of such original thinkers as St. Abelard and Anselm, the other the discovery of the lost books of Aristotle.

The Continental universities led in this renaissance, the universities of Paris and Bologna being the pioneers, though we have proof that a school of smaller importance existed at Salerno even in the ninth century. It is, however, upon these two great archetypal universities that English education in its higher forms was founded. The one, the University of Paris, furnished the type of the guilds of students, the type in which the students legislated and governed largely for themselves; the other, the University of Bologna, stood for the Guilds of Masters, in which the administration devolved largely upon the teaching constituency. Great seats of learning copied the one or the other.

The University of Bologna was founded in the first quarter of the twelfth century and was first famous for its writers on canon law. The University of Paris, established about the same time, became the center to which students flocked from all sections of Europe to study philosophy and theology.

If we begin by taking the University of Paris as the primal spring of Mediæval learning, we are confronted with the remarkable personality of Abelard. University life like all other life starts with a man, a great teacher. A university is never a place nor an edifice, but a collection of persons. Abelard, who at Paris crystallized a university out of the fluid teaching of the Cathedral schools, was a notable and picturesque person in the annals of European education.

Many a tourist has journeyed to Père Lachaise to gaze at two recumbent figures on a tomb beneath a gothic canopy. Abelard, the Prince of Mediæval dialecticians, and Heloise, the brilliant girl whose Greek and Latin studies he directed in his youth, the dignified abbess, who took charge of his body at his death.

The thousand, of students who flocked to Paris to study with Abelard on the mount of St. Genevieve so confounded the scholar that he once confessed that he had begun to think himself the only philosopher in the world. These students with their teacher lived in the world of dialectics, which held the field for centuries and still shows its vestiges in Continental and English theses, the notices nailed on the school doors, and in such terms as the "questionist" for a fourth year student and the "wrangler." Dialectics in those days were based upon authority, usually the authority of Aristotle, who supplied Abelard with his facts. It was a search not for knowledge so much as for "workable opinions." The skill of using learning, or often disguising the lack of it, was placed before the acquirement of real knowledge.

Abelard's collection of contradictory opinions which he gathered from the fathers under the title of "sic et non" was quite impregnable. A fluent speaker would answer his antagonist who said "sic" with the conclusive and undebatable argument "non." If the contention of his disputant was "non," he always had ready at hand the indisputable "sic" from some ancient authority. It was a battle of words and wits while the truth and constructive learning was quite unharmed.

From the beginnings in Paris and Bologna there grew up upon the Continent several early institutional centers, such as the Italian student center at Modena, Salerno, known for its medical pre-eminence, and Reggio at Padua. We also have accounts of institutions about this period at Palencia and Salamanca in Spain and at Mt. Pellier, Toulouse and Lyons in France.

In 1229 came the great dispersal when students were scattered over Europe and England. It was to this event that Oxford and Cambridge trace their early foundation. After Becket's quarrel with Henry II. the English ruler recalled to England the English students and the foundation at Oxford of a "Studium" resulted, an event which was predestined to influence education in a wide and radical manner throughout the succeeding centuries. When a little later the memorable struggle between the Pope and King John of England occurred at Oxford, and the clerks who studied at the Studium came into vigorous and serious contest with the people of the town, the King outlawed the English clergy and the result was the University of Cambridge.

During this period the rapid growth of new schools and the expansion of old ones called for discriminating thought as to the means of differentiation. There were the institutions known as "Studium Generale" which included the necessity of having a number of masters and the inclusion of the seven Liberal Arts, the so-called "Trivium" (Grammar, Rhetoric and Dialectic), and the "Quadrivium" (Music, Arithmetic, Geometry and Astronomy), together with one or more of the higher branches of Theology, Law and Medicine. The Studium Generale was open to all countries. In contrast there were also institutions called Particular Studia in which were taught special subjects, but, as a rule, these were not considered to possess the academic standing of the Studia Generalia.

To give distinction to the schools of wider sweep the Potentates of Europe were asked to give their favor and special privileges to these institutions which were singled out as being entitled to the *jus ubique docendi*. This distinction was given by Emperors and Popes, by the King of France and Emperor Frederick II. of Italy until the possession of the authority of Royalty or Papacy became the distinguishing sign of a Studium Generale. This custom has its reminders in the honorary heads and semi-official relationship of the governing rulers in present-day English university life.

This authoritative approval, however, was particulaly necessary in the Middle Ages when a foreigner was by no means a *persona grata*. The dilemma of a foreign student in mediæval times has been compared to the occurrences in the Lancashire mines fifty years ago, where it was always regarded as a safe working proposition to "'eave arf a brick at a furriner's 'ead."

It was in pursuance of this custom of seeking royal or clerical preferment, that we find Oxford asking for a declaratory or confirmatory Bull, basing its claim upon the general custom and its own growing position, a claim which seems not to have been granted, though her prestige did not suffer materially because of the lack of it. The University of Cambridge, moreover, a less eminent and important institution at that time, was formally recognized as a Studium Generale by Pope John XXII. in the year 1318.

Even prior to these events the word "Universitas" was common as applied to these seats of learning. It signified "an association in the world of learning" and it corresponded to a Guild in the world of commerce. In the words of Mr. Rait the Universitas signified "a union among men living in a Studium and possessing some common interests to protect and to advance." The term meant not so much a variety of studies as a cosmopolitan student body, a kind of special type of mediæval guild.

Gradually this word Universitas came to be used synonymously with the term Studium Generale, and according to Dr. Rashdall, the two terms were used interchangeably in the fifteenth century.

During the period, therefore, included between the middle of the fourteenth and fifteenth centuries, 1350 to 1450, the university as we know it to-day in the West with modifications, came into its heritage as a force to be seriously considered in the nations, and also a force closely connected with both Church and State, with definite forms and fixed terminology and making a widespread and deep appeal to the imagination of the people. Its dignity and seriousness as an institution have been suggested by Dr. Rashdall in his admirable work entitled "The Universities of Europe in the Middle Ages" when he says that "university" as a term was used by mediæval writers to signify "all faithful Christian people."

One can readily see how the rigorous life of the collegers at Westminster came about, when one looks into the Spartan living customs of the Mediæval Universities, since the early training and housing of students did not spell comfort, not to speak of luxury, in the Middle Ages. Oxford was indeed one of the early Universities to secure buildings of any sort, the early Mediæval Universities being but a collection of masters and students. During these years there were no endowments, no thought of quadrangles, no chapels and no dormitories.

Even the Oxford student sought comfort about a "single fire in the middle of college hall and that not lighted until evening." In winter the student studied from 6 to 9 P. M. at a small private table in front of a dormitory window, by light of a rush candle and with no heat. These tables were not unlike the Winchester "toys," the small desks over which the boys still bend in traditional loyalty.

In the minds of Mediæval founders, vices were a problem and many penalties were inflicted upon student practices which are quite unknown under the head of "vices" in the twentieth century. Bathing, for example, was regarded as "unjustifiable license." Skating was also under the ban in certain of these early institutions, while there were strict laws against borrowing and lending of books, no student under twenty-five years of age being allowed to sell a book without the consent of his regent. The penalty for sixteenth century Art students, for such an offense, was a public flogging in his own college. A severe flagellation was the reward of a student at Glasgow who went into the water.

"*Ne Quis Aquas Ingrediatur Aut In Is Natet!*"

Not to make use of the water, still less to swim in it, was the wording of the prohibition. Games also were frequently entirely banned. The Scotch seemed to have a special antipathy against balls and bats, for one finds in the old statutes that anyone applying himself in any way to the "Sphaeristerium" (big enough to include a football), was whipped and expelled from the University.

In 1379 when William of Wykeham founded New College at Oxford on the self governing principle of Merton, training his fellows at Winchester, the Collegiate ideal was fairly fixed. At these colleges conversations must be in Latin, although at Peterhouse we find that French might occasionally be spoken, but English very rarely. In the University of Paris in 1328, it was necessary for a student to make his continuous application in Latin before the Rector prior to being admitted to student life or "scholarity," while at the college in Toulouse the scholars were warned that "only plowmen, swineherds, and other rustics used their mother tongue." Jesus College at Oxford extended this language concession to the privilege of conversation in Latin, Greek and Hebrew. It appears, however, that conversation in the latter two languages never became hilariously popular. The animus of the statute seemed to be aimed against too much talking. These ancient college founders accepted the Biblical maxim that the tongue worketh exceeding great evil, and the only safety against sin, sorrow and idleness was golden silence. In the ancient statutes at Clare we read that not only loss of time, but a tendency to be interested in trifles can be traced to "frequentes collocutionese." The book which was most invariably read was the Bible and the feast days were brightened by singing canticles or by a narration of the history of poems and chronicles.

The day's work in early Oxford and Cambridge began at six o'clock and Dr. Caius, in the middle of the sixteenth century, had his boys tucked snugly in bed by eight at night. No breakfast was supposed to be the rule, though this custom was not strictly followed. Dinner was at ten in the morning and supper was at six in the evening. The whole atmosphere was charged with what one might call simple life; plain living and high thinking had a chance *par excellence* in these early college customs, and the air seemed to be about as cheerful as a New England ice quarry.

The authorities were especially fierce against all varieties of amusement; these functionaries were the original executioners of happiness. To be happy, though a school boy, was the problem. No dogs, no falcons, no dice, and chess, while the scholars at Peterhouse were forbidden "to frequent the taverns, to mix with actors, and to attend theatrical performances." At one Mediæval institution the students of Arts were exhorted to "behave like young ladies." Every night before they were sent to bed the tutor regaled them with a "light and pleasant disputation."

In these early student days the youth was flogged for "making odious comparisons" or for speaking English in a classroom. A farthing was exacted from him for unpunctuality, he was severely penalized for rushing into the dining hall with "violence and greed," and for "nocturnal wanderings," while heresy was a crime the penalty for which was expulsion.

Cardinal Wolsey maintained that it was proper for an undergraduate to be whipped until he had completed his twentieth year. At Trinity College, Cambridge, the offenders were "socially flogged" before the assembled college on Friday evenings, and this was continued until the student was eighteen years of age. At Peterhouse students were forbidden to wear rings. Absence from chapel received the whipping penalty at both Baliol and Christ Colleges. One indulgent founder, of Corpus Christi, Oxford, allowed "moderate hunting or hawking" when a scholar was away from Oxford on a holiday. The same lenient authority permitted a game of ball in the garden for the sake of healthy exercise.

Women were not allowed within the college gates in the early days of Oxford and Cambridge. If at times

* *Educational Foundations.*

men could not be found to wash the students' clothes, a kind of dispensation was secured for the employment of a laundress, but it is expressly stated that said laundress must be old and of unprepossessing appearance. In certain French mediæval colleges, women were allowed to *stand* in the chapel at mass but were not allowed to enter the choir. It was most unusual for a fellow who had not proceeded to Holy Orders to leave the college "uxore ducta."

"Sconcing" existed at Oxford and at Paris, especially at Paris. The ordinary penalty for unseemly noise at prayers was a quart of ordinary red wine which was joyously drunk by the Fellows at the expense of the culprit. If the student displayed temper he was penalized by the libation sentence of a quart of especially good wine, a like punishment being meted out to any student in the Sorbonne who should so far forget himself as to strike a servant. Dr. Rashdall quotes from the MS. Register of the Sorbonne:

"A Doctor of Divinity is sconced a quart of wine for picking a pear off a tree in the college garden, or again, for forgetting to shut the chapel door, or for taking his meals in the kitchen. Clerks are sconced a pint for 'very inordinately' knocking 'at the door during dinner. . . .' for 'confabulating in the court late at night, and refusing to go to their chambers when ordered. . . . 'The head cook is sconced for 'badly preparing the meat for supper,' or for not putting salt in the soup.'"

If one would wish to count his blessings in the advance of university life and discipline since the fourteenth century let him ponder the following account of a student's day as described by R. S. Rait, Esq.:

"The hour of rising was five o'clock, except on Sundays and Feast days, when an hour's grace was allowed. Chapel service began at five-thirty, prayers, meditation, and a New Testament lesson being followed by the mass of the college at six. All students resident in the college had to be present. The reception of commoners, an early instance of which we noted in the College of the Treasurer, had developed to such an extent, that all colleges had, in addition to their bursars or foundations, a large number of 'foranei scholares,' who paid their own expenses but were subject to college discipline, and received a large part of their education in college. After mass the day's work began; attendance at the schools and the performance of exercises for their master in college. Dinner was about twelve o'clock, when either a bursar or an external student read, 'first Holy Scripture, then a book appointed by the master, then a passage from a martyrology.' After dinner, an hour was allowed for recreation—walking within the precincts of the college, or conversation—and then everyone went to his own chamber. Supper was at seven, with reading as at dinner, and the interval until eight-thirty was again free for 'deambulatio vel collocutio.' At eight-thirty the gates of the college were closed, and chapel begun."

If we are to judge by these disciplinary restrictions one would conclude that for the student of the sixteenth century there was very little rejoicing in the days of his youth. The founders and administrators of these Mediæval institutions took themselves seriously. They represented what Holmes would call those "pious and painful" people, not unlike certain religious founders of America's early days, who were credited as having carried a certificate in their faces that their goodness was so great as to make them quite miserable.

## Misuse of Drainage Systems as Sanitary Sewers*

**Lafayette Higgins†**

The facts relative to the misuse of drainage systems as sanitary sewers may be very briefly stated. Any use of common drains for drainage purposes other than for the carrying of ground water or storm water is a misuse of such drainage.

Practically every city, town and village in Iowa where storm water or ground water has constituted an inconvenience or a nuisance has been equipped in some degree with storm water drains. Primarily such storm water drains were intended and used for the disposal of ground water. In the earlier installations, it was generally true that such drainage was intended to dispose of the water which collected in cellars and basements. To some extent such drains were used to drain low lands within such centers of population. Such drains were usually thought of and considered as water drains, and where of any considerable extent, as drainage systems.

Later drainage laws were enacted under which extensive drainage systems might be legally installed, and the enlargement of such legal provisions has given to us the drainage district and the drainage system, as they are now understood and employed.

Beginning with the earliest form of water drains, we find the residents of localities or centers of population installing lines of drain tile in streets and alleys and highways, and connecting up the cellars and basements of residents, places of business and buildings of a public and semi-public character. Ordinarily no trapping was placed in the cellar and basement drains until it might occur that for one reason or another seemingly unnatural odors were noticed in the cellars and basements, or until it was found that vermin could find their way into such cellars and basements through the drains. It also happened that the roof water was discharged through such drains, which practice is now common and proper.

Up to this point of usage, we may understand that no misuse of water drains or drainage systems occurred. However, in the most natural way, and by slow degrees, misuse has grown. The first misuse was the discharge of laundry water and sink water. Possibly in more instances of early misuse it was the discharge of sink water, the washing of kitchen waste and the water of wash basins. The possible dangerous content of such water was not at all understood fifty years ago, and is not understood at the present time by all the people, although within the past few years most people interested in sanitary installations understood something of the possible and probable dangers from such waste water.

From the lavatory comes all of the dirt, impurities or infectious material which the individual receives and retains on the exposed surface or members of the body, and which in the process of washing are immediately removed and discharged as waste water.

The kitchen waste discharged through the kitchen sink contains whatever of dirt and infectious material may exist upon meat, vegetables and other articles of food which are handled and prepared in the various culinary processes which require extensive washing or cleansing, which refuse, fragments of meat, vegetable parings and various kinds of garbage are sent through the kitchen drains to lodge in the cellar drains and undergo decomposition, and probably furnish obnoxious odors and possibly constitute a menace to health. There is also contained in the sink drainage whatever of impurities or infectious material may be washed from the hands or bodies of those engaged in the various kitchen operations.

The laundry wastes are next in importance, and represent a misuse of drainage systems. So far as laundry processes involve the use of boiling water or water at a sufficiently high temperature to render sterile infectious matter or disease germs, we may consider the danger to be minimum. In so far as laundry operations may be carried on with water of insufficient temperature to accomplish the sterilization of infectious material, the danger from such laundry water may be considered sufficient to constitute a misuse of ordinary drainage systems. Perhaps the principal objection to the discharge of laundry water through the cellar or basement drains into an ordinary tile drain lies in the fact that such laundry water contains a considerable soapy content which lodges in such drains, and sometimes results in the clogging of the drains, and in the case of untrapped drains may be responsible for disagreeable odors resulting from the decomposition of the soapy sludge lodged in such drains.

Creamery wastes may be included in this discussion for the reason that in recent years such wastes have been allowed to enter whatever system of sewers or drainage a town might have installed. In some cases, creamery wastes have been sent directly into the drainage tile of a drainage system. Such use of a drainage system is manifestly wrong. Creamery waste is difficult of disposal, sometimes creating a serious menace by reason of the decomposition of such wastes where lodgment of the same occurs in such drains, and the sludge from such waste generally clogs the tile drains, causing difficulty.

The most serious misuse of drainage systems is the direct use of such systems as sanitary sewers.

Such misuse has been quite natural, is sometimes thoughtlessly done, but in some cases the people have really believed that such use was legitimate and harmless.

It is needless to occupy time in enumerating special cases. In some instances the tile drains placed in the streets and alleys now constitute the only sewer system of such towns, and generally in such cases, the drainage system is laid with ordinary drain tile with open joints. In other cases, the drains were built with sewer tile with uncemented joints, and such drains are somewhat better than ordinary tile drains; but such construction is neither sanitary nor safe.

In practically every Iowa town or village where drainage systems have been installed, whether built by either method as above stated, there will be found a considerable use for such drains as sanitary sewers. All such misuse has a beginning, and the beginning is easily made. The property owner desires to install a sanitary toilet in the home. This cannot be done without disposal of toilet wastes. The drain tile is in the street or alley near by. He may have cellar drain or basement drain connected with such line of tile. He simply connects the toilet into the drain. At the same time, or soon after, he may install a lavatory and bath-tub, and connect the same to the outlet tile. He has thus completely installed a modern sanitary equipment in his home. Such an installation attracts attention and is commended. His neighbors do likewise. This is the story of practically every town or village in Iowa where a real sanitary sewer system has not been installed.

Such use of drains is illegitimate, and so far as the writer has investigated, the courts throughout the country so hold.

There is still unsettled the question whether or not a town or village included in a drainage district may legitimately discharge into the drainage system of such district the washings or leachings of garbage or semi-sewage pollution.

So far, it seems to be allowable to discharge the washings of ordinary street refuse into water-ways which would naturally receive the surface drainage of such localities, and this fact may warrant the discharge of the washings of ordinary street refuse into drainage systems which lead into the water-ways furnishing the natural outlet for the run-off water of such localities.

This discussion is perhaps sufficient to indicate the common misuse of drainage systems as sanitary sewers. It may also be stated that some towns are attempting to combine a sanitary sewer system with a drainage system.

In some of these cases, the people have thought that a sanitary sewer system might be allowed to discharge into the drainage systems without the purification of sewage. As before stated, such procedure is not legitimate and should not be permitted.

In other cases, the necessity of purifying the sewage collected by such sanitary sewer systems before discharging the same into the drainage system is understood, and provision is made for such purification. When the sewage is sufficiently purified, or such purification reaches the standards required, such treated sewage may properly be discharged into a drainage system. It is readily understood that such purification may be reached by the use of properly designed and carefully operated sewage treatment plants.

The objection to the installation of a sanitary sewer system and a drainage system, co-ordinately, in a municipality would be that residences or other buildings not located within reach of the sanitary sewer, but located within reach of the drainage system, would in many cases be connected up with the drainage system. It may be assumed that such abuse of drainage systems would not be allowed, but past experience indicates that such abuse would prevail unless the local boards of health of such towns were alert to the dangers involved and would prevent such installations.

The above discussion is sufficient to set forth the common misuse of drainage systems as sanitary sewers. The instances related are real and not imaginary, and the truth of the statements may be verified wherever a drainage system has been installed in a drainage district which includes a part or all of the territory occupied by a city, town or village.

It is therefore apparent that all engineers interested in drainage systems and sanitary sewer systems should be alert, and endeavor to prevent any misuse of drainage systems by using such systems in any degree to dispose of sewage.

*From the *Iowa Engineer*.

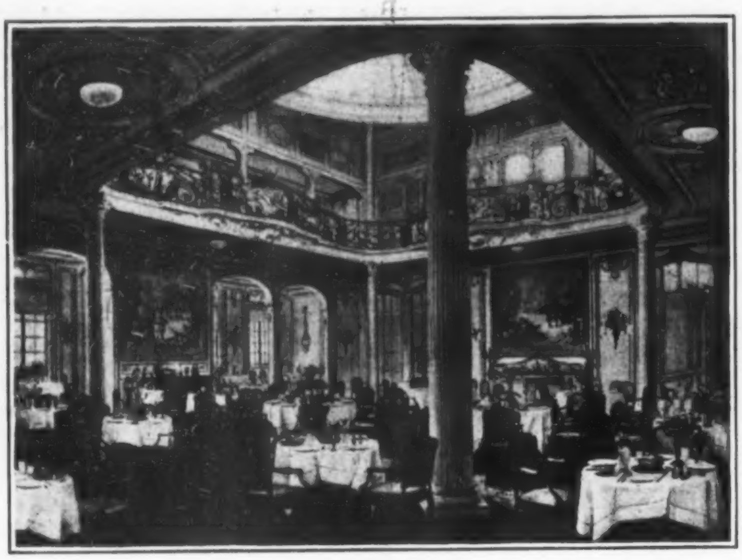
†Civil and Sanitary Engineer, Iowa State Board of Health.

## Brier Roots for Pipe Making

Brier pipes, made from the roots of the French white heath (*Erica arborea*), were first introduced into England in 1859. The plant flourishes in all countries bordering upon the Mediterranean and grows to a height of 38 to 45 inches. In this district it is the custom to cut the long, tough, young shoots each year, bind them together, and sell them for use in sweeping streets in cities and towns. Outside of this, the plant is allowed to grow for three or four years, when the roots will have developed sufficiently to permit cutting them, enough of the plant being left to permit cuttings every three years.

The roots most in demand for pipe making, a certain aroma and brightness of wood being the test, are those obtained from the Tuscan Maremme in the neighborhood of Follonica, Cecina, and Grosseto. They are preferred by manufacturers to those from any other part of Italy, or from Algeria or the Orient. Most of the land in the Tuscan Maremme growing these roots is owned by French and British concerns, who maintain warehouses and workshops on or near their lands where the roots are washed, boiled, and roughly shaped after which they are sorted by size, color, and quality.

They are shipped from these warehouses to France, Great Britain, and, before the war, Germany, where they are made into the pipes known to commerce.—*U. S. Commerce Report.*



**Grand Dining Salon.**

**Children's Dining Room.**

# The "Duilio"

## How Italy Promotes Her South American Trade

That the immense and growing possibilities for Europeans in South America are being realized in Italy as well as elsewhere is proved by the magnificent new liner, the "Duilio," which has just been added to the merchant marine of that country for the South American traffic. This ship was built by an Italian company, while its sister ship, the "Giulio Cesare," which is not yet finished, was ordered from an English dockyard.

We take from *L'Illustrazione Italiana* some data as to construction and equipment of this great boat, which is said to compare favorably with any European liner on the South American course.

*Principal Dimensions.*—Length over all, 635 feet 6 inches; breadth over all, 78 feet 9 inches; draught, with normal cargo, 27 feet; corresponding displacement, 27,000 tons; gross tonnage, 22,000 tons; net tonnage, 14,000 tons; main power plant, 22,000 H. P.; speed on trials, 20 knots.

In order to secure the greatest speed compatible with other requirements, and as economically as possible, preliminary tests were made with various models of hulls and propellers.

The vessel is destined for the La Plata line, running between Geneva and Buenos Aires, and stopping at intermediate ports. The dimensions have been partly determined by the depth of water over the bar at La Plata. The vessel accommodates 217 passengers *de luxe*, 308 second class, and 1,848 third class, which seems to indicate an expectation of large emigration among the Italian laboring classes.

The accommodations for passengers are as follows: On deck A is a charming winter garden and gymnasium. On deck B is a superb ball room, gallery, salons, dining rooms, etc., for passengers *de luxe*. At the stern are the bar and dining room for second-class passengers. On deck C eight cabins for passengers *de luxe*, with dining rooms, bar, etc. Also dining rooms for second-class passengers at the stern. On deck D are eighty-six cabins for passengers *de luxe*, and seventy-two for second-class passengers, also cabins for physicians, steward, barbers, and hairdressers. Here also are the hospitals, the printing shop, dark room, linen closets, etc. There are twenty-five private baths and twelve public baths on this deck. Decks E, F and G have some accommodations for first-class and second-class passengers, but are chiefly given over to emigrant quarters. All quarters are heated and ventilated by thermo-tanks and mechanical ventilators. There are hospitals with separate staffs for ordinary ailments and for infectious diseases.

The decorations are exceedingly handsome and artistic, being modeled on the styles of the "Louis'" in the golden age of French art from 1600 to 1800 A. D. The concert salon is richly decorated in the style of Louis XV, with gilded ornaments in relief. This room is 52 feet 6 inches long and 42 feet 6 inches wide. There are two galleries, meant for libraries, decorated with polychrome panels and well filled with books. A vast hall, 59 feet by 42 feet 6 inches, is in Louis XIV style, with panels of oak carved in full relief. Two writing rooms are in Louis XIII style, with partitions of carved fumed oak and painted ceilings. A great dining room, 246 feet long, 42½ feet wide, 26¼ feet in height, is in the Regency style. It has lacquered panels, a balcony for music and a large decorative curtain. It holds 250 people, seated at small separate tables.

On a lower deck are two restaurants decorated in Regency style, with panels of painted silk; a special dining room for children, decorated in Holland style, with walls and ceiling of oak; and a great bar, 42 feet by 23 feet, decorated in Italian style, with panels of inlaid wood.

The chief entrance vestibule on the same deck, about 65½ feet long by 36 inches in width, is in Louis XIV style, in oak, and with booths for the sale of flowers, books, papers, etc.; and leading from it are passages running in every direction throughout the ship.

The cabins *de luxe* contain bed-room, sitting-room and bath. They have silk-hung walls, carved panels, painted ceilings, telephones, steam heat, and hot and cold water, both salt and fresh.

The second-class dining room is also large and handsomely decorated, seating 200 at small tables.

The Societa Ducrot, which had charge of the decorations, intrusted some of them to the best Italian artists. In the great hall the monumental fountain is by the sculptor Domenico Trentacoste. Other well-known artists executed frieze, paintings and wrought iron work.

*Mechanical Equipment.*—Loading is accomplished rapidly and silently by hydraulic cranes, requiring few hands to operate. The rudder is controlled by steam, with a double motor, a principal motor and an auxiliary of the same power. Both machines are operated by means of independent telemotors.

The refrigerating plant makes use of carbonic anhydride and consists of two twin plants entirely independent of each other, of such capacity that one alone, working 20 hours per day, can maintain a temperature not over 10 deg. Centigrade in all the meat and fish rooms, and suitable temperature in the other rooms.

Two large anti-rolling tanks, modeled after those on the Cunard liner "Aquitania," are provided to keep the ship steady in rough weather.

The structure of the ship is plainly seen in the main cross section and conforms to the recommendations made by the International Commission at London for guaranteeing safety of ships and passengers. In conformity with these the double bottom does not stop at the lower part of the boat, but is prolonged up the sides. The doors of the bulkheads can be operated from the bridge.

The principal transverse bulkheads are continued as high as deck D, and their number and disposition is such as to guarantee the buoyancy of the ship with four consecutive compartments filled in case of serious accident to the hull.

For the safety of passengers and crew in case of shipwreck there are a number of life-boats, including motor life-boats and pontoon rafts, amply sufficient to hold all possible members of both, i. e. about 2,850 persons.

*Propelling Machinery.*—The main engines consist of a group of Parsons turbines in series, acting on four shafts and screws. The group of turbines consist of a high pressure turbine acting on the starboard shaft; an intermediate turbine acting on the port shaft, and of two low pressure turbines acting on the two central shafts. Between the casing of the low pressure turbines are located the astern turbines. All the ahead turbines are of the reaction type; the astern turbines are of the combination type of action and reaction.

There are six double ended and four single end return flue boilers, with four furnaces at each end, and four single end boilers, all provided with Howden forced draft. The service pressure is 135 pounds per square inch. In the maneuvering only the low pressure turbines on the central shafts are used, and these, as well as the astern turbines, take direct steam. Suitable valves automatically close the connection between the central turbines and the two lateral ones. The power is equally divided among the four shafts. The total power developed is 22,000 H. P. The number of revolutions, when the turbines develop this power, is about 1,740 per minute. The power available for reverse action is 60 per cent of the total power.

The propellers are three-bladed, cast in one piece of manganese bronze, 9 feet 6 inches in diameter, and about 8 feet pitch.

*Boilers.*—The shell of the monoface boilers is made in a single ring with a single longitudinal joint; the shell of two-faced boilers is made of three rings, each with a single longitudinal joint.

The furnaces are of the Morrison type. The boilers are operated with forced draft of the Howden system. Eight fans provide for going at full power. These fans are each driven by a steam motor of the closed Howden type, connected directly with the shaft of the wheel. All the motors operate at the normal pressure of the boiler.

The equipment of the "Duilio," including boilers, refrigerating plant, electric light and power system, etc., is said to be of the most modern type, with improvements which do much to assure the comfort and safety of the passengers. The vessel was built by the Ansaldo Dockyards, under the supervision of the Registro Nazionali Italiano and the Lloyd Register.

The lines of the hull were determined on after an experimental study of three models, resulting in the adoption of a type having valuable improvements as regards economy of propulsion. This quality was increased by the adoption of turbine motors instead of the usual reciprocating engines. The turbines realize a sensible economy of weight, which goes to the benefit of the cargo, which is important because of the limit of immersion above referred to, due to the bar of the La Plata. The vessel is quite high at the prow, about 49 feet above the sea, enabling it to proceed at full speed even in very rough seas.

The portion of the vessel below the water line has a double bottom, high enough to permit one to walk within it. This extends from bow to stern, and is subdivided into a large number of compartments. The double bottom has a collective capacity of about 106,000 cubic feet, and serves chiefly to hold water ballast, and supplies of drinking water and washing water. The interior between the division walls and the decks is subdivided into a great number of compartments, so that in case of damage the vessel could be flooded

On the Shelter Deck.

In the Gymnasium.

in a long zone comprising four consecutive compartments without ceasing to float.

Some interesting details are given as to the construction. In modern practice before the hull is laid upon the stocks a minute study is made of the conditions likely to obtain at the time of launching, and accurate calculations are made correspondingly. These take into account the estimated weight of the hull when launched, the probable season of the year at which the launching will occur, the nature of the coast line, the depth of excavation of which the adjacent sea-bottom is capable, etc. Consideration of all these elements is necessary to establish the most convenient plane of launching as regards elevation and inclination in relation to the vessel, and so as to retain within moderate limits the depth of immersion of the hull and the forces which are exerted upon this and upon the cradle during the act of launching.

To give an idea of the magnitude of these forces and of such a depth it will suffice to state that when the "Duilio" was launched the pressure at the extremity of the cradle on the stocks at the most critical moment amounted to 2,600 tons, since there was a pressure of about 1,000 tons per square meter of the surface under pressure; that is to say, about ten times the pressure which the tallest palaces exert on their foundations. It is necessary to make proper provision for such forces.

The depth of excavation of the bottom of the sea at the lowest point required for the vessel to be freely immersed without touching bottom was about 36 feet below sea level, whence the necessity for a very powerful dredge to make the excavation and accomplish it quickly during calm weather.

The study of the cradle on which the vessel rests must also precede the actual construction. The launching way is a strong bed of wooden beams and planks which extends the whole length of the vessel, and which must be extended before the launching by means of a raft for a considerable distance into the sea. This must be placed in position and secured to the bottom so as to be in perfect alignment with the stocks on land, an operation which is far from easy, and is often disturbed by the waves. And it is because of this circumstance that it is not possible on an open coast to determine the day, and still less the hour, of launching, as well as on a sheltered coast or in ports and estuaries. To facilitate the launching, both the ground ways and the sliding ways are well greased at the time of launching. If the weather is cold there may be difficulty in starting the vessel down the incline. To avoid any delay use is made of suitable hydraulic rams to exert a pushing action.

At the launching of the "Duilio" four such hydraulic rams, having a total power of 1,200 tons, were provided; but it was only found necessary to open the pressure valve a trifle to start the vessel.

Some idea of the immense amount of labor required for the construction and launching of such an ocean greyhound is given by the relative weights of the various parts of the "Duilio." The hull alone, without the motors, which themselves weigh over 3,000 tons, weighs more than 14,000 tons. Each of the boilers weighs 105 tons and each of the turbines 120 tons. Such weights require enormous floating cranes, of great height and power, to lift and place machinery, etc.

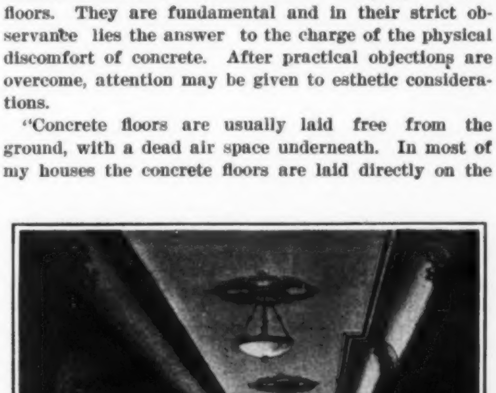
## Concrete Floors in the Home

The dusty, spotty and generally untidyfloors of concrete that are but too frequently seen in public buildings have tended to give that useful material a bad reputation, and that it is a suitable material for a dainty home, seems to many an incredible suggestion. It must be realized, however, that concrete is really a new material, whose qualities and possibilities are not yet fully understood, and the mistakes of its earily users should not too hastily be charged against the material itself.

In a recent issue of the *Sunset Magazine*, Irving J. Gill, an architect of Los Angeles, tells a surprising story about the use of concrete as a floor material for the home, and, according to his experience, this should be the ideal floor, far surpassing anything else that has yet been employed. He says:

"To overcome the popular prejudice against concrete floors is the business of the architect. There are certain definite conditions to be observed in laying concrete floors. They are fundamental and in their strict observance lies the answer to the charge of the physical discomfort of concrete. After practical objections are overcome, attention may be given to esthetic considerations.

"Concrete floors are usually laid free from the ground, with a dead air space underneath. In most of my houses the concrete floors are laid directly on the



The Gallery.

ground (in California) doing away with air circulation under the floor and giving a more equable temperature. They are raised at least 21 inches above the surrounding ground, and particular attention is paid to the preparation of the earth bed. After the foundation is laid the ground is puddled and tamped until very firm. Over the surface is spread from 4 inches to 6 inches of sand or sandy loam. Then the concrete is put on. If one part of the floor is below grade, the ground under it is carefully drained, after which the layer of sand prevents moisture from coming through.

"The main body of rough concrete should be reinforced to one-third of one per cent to prevent cracking, and scored to give a key to the top coat and prevent its loosening from the bottom. The finish coat should be reinforced with No. 18-ga. ½-inch mesh galvanized wire to prevent cracking.

"From four weeks to six weeks should be allowed for concrete floors to dry. During this time there is a continuous process of absorption and radiation of heat until a mean temperature has been reached, after which the temperature of the floor is more equable than wood.

"To cover a concrete floor with wood is about as logical as to cover concrete sidewalks with boards. Everybody who has lived on concrete floors laid according to the given specifications has been wholly converted to them and would never again be bothered with the care and trials of wood floors. It is not, of course, expected that concrete floors should be left bare. They should be partly covered with rugs, the same as a polished wood floor. Incidentally, when properly laid, waxed and polished, cement floors are ideal for dancing.

"When troweled and finished to a gloss, concrete floors do not mar or scratch. They should not be scored or marked off into squares or designs. The natural crazing of the top coat is far more pleasing. I have found no cement floor paint that produce a good effect. The hard, monotonous flat colors are unpleasing, the paint soon wears off and shows the cement. Instead of using paint, I mix color with the cement, usually tones of red and yellow, red and brown or yellow and brown slightly mottled. Tempered by the gray of the cement these colors produce neutral tones that are a splendid background for rugs and furniture. When quite dry, the cement should be cleaned with a weak solution of ammonia and water, given two coats of Chinese nut oil to bring out the color, then finished with a filler and waxed like hardwood. Well done, this treatment gives an effect of old Spanish leather.

"It is quite as impossible to tell how to lay and finish a concrete floor to bring out all its potential beauty as it is to give exact rules for painting a picture. Specifications and instructions carry one just so far, but beyond that point each builder must study out the problem for himself. It takes the knack or the inspiration or the gift —whatever its name—that differentiates craftsmanship from mere mechanical perfection, that raises the artist above the artisan, to make a concrete floor the thing of beauty it can and should be.

"Before it has set, cement is a wonderfully plastic material, more wonderful than clay. It can be colored, modeled, shaded and surfaced, and then of itself hardens into an everlasting expression of the workman.

"The protest against ordinary concrete floors is the unconscious demand for the thing well done. At heart we are never satisfied with any work that is not done right, and concrete floors will not come into their own until architect and workman study them as an art.

"The cement floors in the home of Homer Laughlin, in Los Angeles, forecast the possibilities of the future. Sprawling there, his soul in his work, with great sweeps of his trowel, an artist wrought in that plastic, responsive material, blending the colors marvelously in the broad central spaces, coaxing them to a rare harmony of tone and exquisite finish, and around the outer edges he carved in low relief the lines of acanthus and other simple conventionalized leaf forms. In the entrance hall, with big, free strokes he limned the feather-like frouds of a palm, using his color with consummate skill and an artist's feeling. The appeal of this most modern manifestation of ceramic art is far more subtle than that of the mosaics, which were the acme of floor-making among the Greeks and Romans, and it has the singular advantage of being within reach of beauty lovers of moderate means.

"Concrete floors are cheaper than wood for the first story; they are enduring, they require a minimum of care, they are comfortable and healthful when laid right, and they can be more beautiful than any other floor."

## The Turquois.

It has been called to our attention that the matter and illustrations of the article on "The Turquois" that appeared in the issue of the Supplement for May 27th, No. 2108, was derived from a work by Joseph E. Pogue, entitled "The Turquois. A Study of its History, Mineralogy, Geology, Archeology, Mythology, Folklore and Technology." Third Memoir: Memoirs of The National Academy of Sciences, Vol. XII, Part. II.

# Antimony and the War

## Principle Sources of the Metal, and Notes on Its Reduction

ANTIMONY, together with its sulphides and oxides, has been made contraband of war both by this country [England] and France. Among the minor metals which have been greatly affected by the war, antimony is the most important. Its main use and value is as a hardener of lead, which renders it important for munitions. Thus the British bullet has a cupro-nickel sheath; its core consists of two parts, the front portion being an alloy of aluminium 90 per cent, and zinc 10 per cent, or pure aluminium, and the rear portion an alloy of 98 per cent lead and 2 per cent antimony, in an envelope of 80 per cent copper and 20 per cent nickel. We are entirely dependent on outside sources for supplies, and import both ore to be smelted and refined in this country and crude antimony and regulus. During the Autumn the war demand developed. Russia bought large supplies in this country, Japan, and the United States, where it was stated all available stock was bought up. The total Russian demand during 1914 exceeded 2,500 tons; at least an equal quantity was purchased on behalf of other nations, and Japan also competed for supplies. Armament-makers, as well as cartridge and shrapnel manufacturers, both in Europe and the United States, have been large buyers. It seems probable that the demand will continue, possibly on an increasing scale, to the end of this year. Prices may increase, for stocks both here and abroad are at the lowest level, and production cannot keep pace with the increasing demand.

The main sources of supply are limited to four countries, as shown by details below. Apart from commercial antimony obtained from ores and smelted, there is a secondary source of supply from gold and silver ores. When these are smelted the antimony combines with the lead of the charge to form antimonial lead. By this indirect means a considerable output of antimony is produced, though it goes to the market as antimonial lead, for which there is a large demand, and from which the metallic antimony is never separated, as the alloy has been found to be extremely useful for many purposes; in fact, the ordinary commercial uses of antimony are in alloys. The antimonial leads generally average 10 to 11 per cent antimony; some 2,000 or 3,000 tons are obtained annually from the remelting of discarded alloys, including such materials as waste type, babbit metal, journal bearings, and so on. An alloy of antimony (or antimonial lead) is used for type metal, as the antimony causes a slight expansion on cooling, ensuring complete filling of the molds, resulting in clean-cut edges to the letters. The alloys are also used for stereotype-plates and britannia metal, which consists of 10 per cent antimony and 90 per cent tin; Babbit anti-friction metal and other bearing metals; linings for acid tanks; shot (thus Mauser ammunition contains 5 per cent of antimony); clock-cases and other articles, for which a fairly hard metal, to be gilded or otherwise finished, is desirable. Antimony lead has been used as an adulterant in solder, and is considered a very objectionable element, especially when used for sealing cans holding provisions. The use of antimony salts and oxides is comparatively large, the trioxide is used as a pigment in place of white lead and zinc oxide, and antimony oxide is used to some extent as a substitute for oxide of tin in the enamel and ceramic industry. It is also used for making the gloss required to coat iron in enameled ware; as a reducing agent in chemical work, and as a detector of alkaloids and phenol. The trichloride is used in bronzing iron, especially gun-barrels.

Antimonial lead, which is now used in very considerable quantities for various industrial purposes, as stated above, and which is a by-product resulting from the smelting and refining of silver, is much cheaper than similar material obtained by combining pure antimony with lead. It is not usual, therefore, to separate antimony from antimonial lead. When obtained in the refining of silver the antimony is very impure, the chief impurity being arsenic. The removal of the arsenic has involved some difficulty, and until comparatively recently it was not unusual to find several per cent of this metal in the antimonial lead, considerably decreasing its value; the various alloys made from it were, therefore, of an inferior grade. The following process appears to have yielded good results; it is based on the fact that molten caustic soda, when in contact with the molten antimonial lead, removes the arsenic without appreciably removing the antimony. Three receptacles are placed side by side, step-wise; the highest contains the impure lead, the lowest the refined lead, while in the intermediate one the refining is effected. The impure lead in the first receptacle, after being melted, is allowed to flow in a small stream through a pipe placed in the bottom of the receptacle into the second receptacle containing molten caustic soda. As the antimonial lead slowly passes through the molten caustic soda, a large surface is exposed and the arsenic is removed from it. From time to time the caustic soda must be replaced by a fresh supply. Caustic potash gives similar results. In the bottom of the intermediate receptacle there is a bent pipe, or trap, through which the refined lead flows into the lowest of the three receptacles, from which it is poured or ladled into moulds.

This pipe prevents the caustic soda from flowing into the refined lead receptacle along with the lead. Over the top of the intermediate receptacle a basin is placed, through which the impure lead passes, constructed so as to break up the stream of lead into as small particles as possible, thus exposing the maximum amount of surface to the action of the caustic soda. While the trap between the second and third receptacles practically prevents the caustic soda reaching the lowest receptacle, a small quantity may get through, and to remove this some hydrogen sodium sulphate in the anhydrous state is added to the refined lead. This neutralizes the caustic soda, and by rendering it inert prevents it attacking the lead and antimony or covering the lead when ladled out into the molds. After the sulphate has acted, the slag on the top of the metal is skimmed off. When the amount of arsenic present in the lead is small, and the caustic soda acts rapidly, it may be desirable to introduce a "retarder" with the soda to prevent it attacking the lead and antimony. Iron scale may be used for this purpose in the proportion of 20 parts of iron scale to 80 of caustic soda.

Oxide of antimony (*stibium oxydatum*) $Sb_2O_3$ or $Sb_4O_6$, exists naturally as white antimony and as antimony bloom. It is produced by roasting crushed antimony ore, alternately oxidizing and reducing it, and by treating the antimony vapors with steam. The process of extracting antimony from the ore is a simple one, but there are several processes employed. The crude and commercial antimony is the ore separated from the associated earthy gangue; this operation is performed by simple fusion. From this there are several means of obtaining the regulus of antimony. The raw antimony, whether obtained direct from the ore or from the purified sulphide, must be calcined in order to separate such impurities as arsenic and sulphur. In the direct process of obtaining antimony, the ore is smelted with some alkaline slag and old scrap-iron. When this combination has completely fused, it is poured into conically shaped molds, and this mixture, after cooling, consists of impure antimony and sulphide of iron. There are several methods available for purifying the regulus; one of the simplest is to charge each of a number of crucibles with this regulus along with soda, common salt and pure oxidized antimony ore. When sufficient heat has been applied, the foreign impurities, or metals, become oxidized and scorified, and the antimony is thus obtained. It is a bright, silver grey metal, brittle, and readily pulverized.

The roasting of antimony is very similar to the roasting of lead matte; until recently it was roasted either in hand reverberatory furnaces or in single-hearth furnaces. The essential point of the furnace is the absolute control of temperatures. In roasting antimony, should the temperature rise to about 350 deg. Cent. in the early stages of the roast, there is a tendency toward fusion; but later in the roast the temperature may be raised considerably beyond 350 deg. Cent.; it is, in fact, quite possible to do so without any difficulty arising. The fusion takes place in the early part of the roast. The control of temperatures in improved furnaces enables the heat of the sulphur to be utilized when present. The older system of hand reverberatory furnaces entailed a large fuel consumption.

Below we give an account of the chief sources of supply of antimony at present:—

*China.*—Of the world's total output of antimony three fourths of the ordinary 99 per cent. grade comes from China; the cost of production is lower than in any other country. No less than 100 mining companies have been established, and eight smelters have been erected, but they are not as yet all at work. The important companies are the Wah Chang Mining and Smelting Company of Changsha, and the Pao Tai Mining and Smelting Company of Wuchow. Antimony is not at present known to occur in Northern China; the main source of supply is the western central region; the trade routes by means of which the mineral wealth of Central China reaches the coast are the Yangtse river, with Shanghai at the estuary, and the West river. The total exports exceed 12,000 tons yearly, the main portion being shipped from Changsha and smaller quantities from Yochow, Hankow, Wuchow, and some other ports. Amoy is a district from which antimony may be exported in considerable quantities in the future.

The bulk of the Chinese output is shipped as crude ore, to be smelted and refined in Europe. Reliable returns for 1914 are not yet available; for recent years they have been as follows:—

| | 1910. Tons | 1911. Tons. | 1912. Tons. | 1913. Tons. |
|---|---|---|---|---|
| Ore | 5,665 | 6,700 | 2,020 | 4,250 |
| Crude | 6,535 | 6,875 | 13,310 | 12,820 |

The ore exported to this country has been as given below:—

| | Tons | Tons | Tons | Tons |
|---|---|---|---|---|
| Ore | 632 | 1,965 | 970 | 2,166 |
| Crude and regulus | 5,817 | 683 | 1,107 | 2,040 |

The Japanese output of antimony is rapidly declining, as the following figures indicate:—

| Year. | Tons. | Year. | Tons. | Year. | Tons. |
|---|---|---|---|---|---|
| 1901 | 595 | 1905 | 306 | 1909 | 185 |
| 1902 | 667 | 1906 | 324 | 1910 | 140 |
| 1903 | 630 | 1907 | 266 | 1911 | 105 |
| 1904 | 456 | 1908 | 212 | 1912 | 76 |

The natural inference from these figures is that the mines have been exhausted.

*North America.*—Antimony in any considerable economic quantity is of somewhat rare occurrence throughout the entire North American continent, including Canada. It has not been produced in quantity in the United States. So recently as 1908 there was no output; in 1909 only one lot of ore was mined and marketed—in Humboldt County, Nevada; all supplies of ore required were imported—during 1908 to the value of 200,000*l*. No antimony was produced in the United States from domestic ore in 1912, and very little during 1913, but the ore occurs in many localities—Washington, Idaho, Utah, California and Oregon The high prices now obtainable may result in these deposits being opened out. The United States import large quantities of crude and regulus from this country; in fact, the bulk of our exports go to America. The total imports of antimony into the United States from all countries has been as follows:—

| 1911. Tons. | 1912. Tons. | 1913. Tons. | 1914. Tons. |
|---|---|---|---|
| 4180 | 6215 | 8700 | 6400 |

The United States imports from China and Hong Kong are as follows:—

| Tons | Tons | Tons | Tons |
|---|---|---|---|
| 1,500 | 2,175 | 3,185 | 2,000 |

Probably the bulk of the antimony imported into the States from this country is of Chinese origin, and efforts are now being made in America to import it direct, which may not succeed. Large quantities of antimony are now required in the United States to execute orders for bullets on an enormous scale.

There are both mines and smelters in Mexico, one is in course of erection in San Luis, Potosi; by the time mining and transportation conditions permit ore to be produced it will be ready for operation. The smelter will have a capacity of 3,000 tons per annum of refined antimony and will employ at least 150 men. The output is more likely to go to America than Europe. The ores to be worked up will be obtained from mines in Queretavo and San Luis, Potosi. At present there is only one antimony smelter working in Mexico, located at Wadley, a small station about 100 miles north of San Luis, Potosi. The Wadley smelter is not equipped for finishing the product, and has exported its output to this country for further refining. This smelter has been worked for about fourteen years, and has drawn a large part of its ore from the Catorce district.

The quantities of crude antimony and regulus sent from Mexico to this country have been as follows:—

| | Tons. | | Tons. |
|---|---|---|---|
| 1910 | 3,788 | 1912 | 3,296 |
| 1911 | 3,907 | 1913 | 2,345 |

*Canada.*—In Canada there has been a small output of antimony from Nova Scotia; but no Canadian antimony has been sent to this country since 1911, and then only in very small quantities.

A few years ago interesting and apparently important deposits were found in the northern portion of the Yukon territory. They are limited in their occurrence, so far as ascertained, to a small area 8 or 10 square miles in extent, known as Carbon and Chieftain Hills, about 33 miles above the point where the Wheaton River flows into Lake Bennett. The deposits are not more than 10 or 12 miles north of the sixtieth degree of latitude, forming the British Columbia-Yukon boundary. The deposits can be reached from Vancouver by steamer, then rail followed by road. Oddly enough, these deposits were discovered as far back as 1893 by two prospectors, who died without disclosing the locality, and they were rediscovered about five years ago. The veins vary in width from a few inches to 5 feet, and consist principally

of stibnite, sphalerite, tetrahedrite (gray copper) galena (silver bearing) antimony and ocher; the latter occurs near the surface as a product of oxidation. The veins are occasionally wholly made up of stibnite. The gangue material is generally quartz, occasionally barite.

*South America.*—There is a small output from Chili. In Peru antimony, as well as other ores, occur in the Sierra, or plateau; at present the output is very small owing to transport and other difficulties. The general height of the outcrops above sea-level ranges from 12,000 feet to 14,000 feet, at which elevation there is snow during the winter months, but for mining the climate may be described as mild and suitable. Antimony is also found in Ecuador, but the deposits have not yet been opened out. Many years may elapse before output in quantity can be chronicled.

*France.*—French antimony, reduced both from native and imported ores, supplies the home demand, and before the declaration of war found a market in the United States. The output may be approximately estimated to be as follows:—

| 1910. | 1911. | 1912. | 1913. |
|---|---|---|---|
| Tons. | Tons. | Tons. | Tons. |
| 4550 | 4790 | 5430 | 5900 |

*Various.*—No antimony ore has been produced in the United Kingdom since 1892; before that date small quantities were raised from veins in Scotland and North Cornwall. Extensive smelting and refining is carried on by seven important companies, the works being located as follows:—One each in Runcorn, Newcastle-on-Tyne, and St. Helens, and four in London, with a branch in Patricroft, near Manchester.

Small quantities of ore are imported from Turkey, as shown below:—

| | Tons. | | Tons. |
|---|---|---|---|
| 1910 | 298 | 1912 | 1,091 |
| 1911 | 761 | 1913 | 402 |

Australian exports of antimony ore are sent to this country in steadily increasing quantities, to be worked up in our smelters.

| | Tons. | | Tons. |
|---|---|---|---|
| 1909 | 531 | 1912 | 1,338 |
| 1910 | 657 | 1913 | 2,030 |
| 1911 | 1,001 | .... | ..... |

Other supplies come from Italy, Austria, Bohemia, Turkey and New South Wales. The Italian antimony deposits occur in Sardinia and Tuscany, but the output is not large.—*Engineering.*

# American Flags

## Interesting Relics in the National Museum

The American flag collections of the U. S. National Museum include some rare examples of our flag, indicative of its development in several historical periods, its many changes, and its gradual standardization.

It is interesting to note that during the Revolution the flag had 13 stars; in the War of 1812, 15; in the Mexican War, 29; in the Civil War, 35; in the Spanish-American War, 45; and to-day, 48. The American flag is among the oldest of national flags, being older than the present British Union Jack, the French tricolor, and the flag of Spain, and many years older than the flags of Germany and Italy, some of which like those of other countries are personal flags, or those of reigning families.

There are no early colonial flags, such as were used by the individual colonies and militia regiments before the flag of the United States was established by Congress on June 14th, 1777, now celebrated as Flag Day. This act required "That the flag of the United States be thirteen stripes, alternate red and white; that the union be thirteen stars, white in a blue field, representing a new constellation," but did not define how many points the stars should have, how they should be arranged, nor make provision for additional ones.

The navy immediately adopted this flag but the army was much slower to act. Representative of the early stars-and-stripes type, there is a twelve-star flag said to have been used by John Paul Jones during the war of the Revolution. It measures 10½ feet by 6¼ feet, and was presented to Lieut. James Bayard Stafford, U. S. Navy, on December 13th, 1784, by the Marine Committee of the Continental Congress, as a reward for meritorious services during the Revolution, coming later to the Smithsonian Institution as a gift from Mrs. Harriet R. Perry Stafford.

Another flag of the very highest historic value is the original "Star Spangled Banner," which flew over Fort McHenry in Baltimore during the bombardment on September 13-14th, 1814, and was the inspiration for Key's anthem. This Fort McHenry flag is of the fifteen stars-and-stripes type, adopted by an act approved by President Washington, January 13th, 1794, which took effect May 1st, 1795, after the admission of Vermont and Kentucky. It measures about 30 feet square, is much battered and torn, with one star missing, but this great historic souvenir has lately been preserved by quilting it on heavy linen cloth, and remains one of the country's most precious relics. From 1795 this form continued as the standard flag until President Monroe's administration, when Congress enacted that it should thereafter be of thirteen stripes, with the addition of a star for each new State, commencing July 4th, 1818.

It seems that the army never carried the national flag in battle, though we have record of its use as a garrison flag from about 1787 or 1798 to 1834, until 1846. Bodies of troops carried during this period, and before it, what was known as national colors, or standards, of blue with the arms of the United States emblazoned thereon, comprising an eagle surmounted by a number of stars, and with the designation of the body of troops, as infantry, artillery, etc., inscribed on a scroll. In 1834 the artillery were given the right of carrying the stars and stripes as recorded by the War Department regulations, the infantry and cavalry still using the national arms with an added scroll in the eagle's beak bearing the words: "*E pluribus unum.*" These flags remained the colors of the infantry until 1841, and the cavalry until as late as 1887, when they were ordered to employ the stars and stripes.

So many styles and forms of the stars-and-stripes flag were in existence in 1837 that certain foreign governments found it necessary to make inquiry of this government just what the official flag was, resulting in the publication in 1852 of a careful study of the subject by him who later became (General) Schuyler Hamilton.

However, it was not until 1912 that very definite specifications were drawn up. Under President Taft's administration representatives of the various government departments conferred on proportions and other details of the national flag, resulting in an Executive order, dated October 29th, 1912, which tended to standardize the stars and stripes, and yet further specifications were found necessary only recently.

The history of our flag indicates that the "stars and stripes" was not carried by troops in battle until the period of the Mexican War, 1846-47. Several flags of this period are in the Museum collections. Among them is a flag of thirteen stripes and stars carried throughout the war by the battalion of volunteers which enlisted from Maryland and the District of Columbia, and the flag of Company I, fourth regiment of Indiana Infantry, of thirteen stripes, with an eagle in the field.

Ten flags of the collection pertain to the Civil War. The garrison flag of Fort Moultrie, S. C., lowered when the command evacuated that fort to assemble at Fort Sumter, December 26th, 1860; a boat flag flown by Commander Charles S. Boggs, U. S. Navy, when he left the gunboat "Varuna," sunk in an engagement between a Confederate flotilla and the Union fleet under Admiral Farragut, below New Orleans, April 24th, 1862; a signal flag of white cloth with painted stars and stripes; headquarters flag of Maj.-Gen. Benjamin F. Butler, U. S. Volunteers, flown at Fortress Monroe, Virginia, in 1861; the flag raised at New Orleans by its citizens upon the occupation of the city by the Union forces under Maj.-Gen. Butler, May 1st, 1862; the remains of the flag carried in the three days' fight at Salem Heights, Virginia, May 3-5th, 1863, when three color sergeants were killed, though the banner never faltered or fell to the ground; Gen. Hazen's garrison flag, hoisted at Fort McAllister, Ga., after the surrender of the fort to the Union army, December 13th, 1864; the flag flown on the U. S. S. "Kearsarge" when she sank the "Alabama," deposited in the National Museum by Lieut. Herbert Winslow, son of Rear Admiral Herbert Winslow, commander of the "Kearsarge" during this action; headquarters flag of Maj.-Gen. E. O. C. Ord, U. S. Army, flown in Richmond, Va., in 1865; and the flag of the First Pennsylvania Volunteers, found in the Capitol at Richmond in 1865 by Maj.-Gen. Ord.

### Stone for Road Material

It has been found that igneous and nonfoliated metamorphic rocks, owing to a preponderance of firmly united silicate minerals combined with uniformity in structure, offer a greater resistance to abraison than other rock types, coarse-grained varieties being less tough and having inferior indicated wearing properties to those of finer grain in which the mineral components are more closely intergrown. Excessive quantities of glass in volcanic lavas and high percentages of readily cleavable mica and feldspar in plutonic rocks lower their toughness and indicated resistance to wear; on the other hand, appreciable quantities of hornblende and augite have an opposite effect. Foliated schists and gneisses parting readily along planes of schistosity are low in toughness while sandstones and limestones owe their inferior indicated resistance to wear either to incomplete consolidaton or to a preponderance of softer carbonate minerals and clay.

It has been demonstrated, furthermore, that the shape and physical character of the smaller rock fragments used in road making are largely dependent upon structure and mineral composition, coarse-grained feldspathic rocks breaking down readily into rectangular fragments, owing to feldspar cleavage, whereas the finer-grained trap screenings are more wedge-shaped and tougher. The chips broken from loosely compacted sandstones and schists are rounded in shape, approaching somewhat the outline of abraded quartz grains, or they appear flat and lath-shaped in accordance with the foliated structure of the later rocks. The effect of weathering on the physical properties of rocks varies with the structural character and composition of the rock and the physical properties and relative abundance of alteration products. Thus the indicated wearing properties of igneous and metamorphic rocks are, in general, benefited by hard secondary epidote, zeolite, and hornblende, while an abundance of softer alteration products, such as chlorite, serpentine, and kaoln, lowers the indicated resistance to wear.

In sedimentary limestones and dolomites it has been found that quartz accompanied by a little kaolin has greatly increased their toughness and resistance to abrasion, whereas compact sandstones, having about 15 per cent of secondary constituents are among the most resistant of sedimentary rocks. The effects of weathering have been found most pronounced in regard to the cementing property of road materials, which is seen to vary directly, but not in the same ratio, with the amount of soft scondary minerals, in part amorphous. Where these materials are replaced, even to a limited extent, by harder, more crystalline products of alteration the binding properties are proportionately lowered. These relations have been plotted in curves for the common crystalline rock types and gravels.

Finally, the slaking properties of rock powders have been investigated with the result that acid crystalline rocks are found to slake rapidly excepting samples that contain relatively low average percentages of mica and quartz and abundant hornblende and epidote, while the slaking qualities of basic igneous rocks and sandstones are dependent mainly on the relative abundance of colloidal products of rock weathering, such as kaolin, limonite, and chlorite.

The results obtained from the present investigations indicate the following:

(1) Igneous and nonfoliated metamorphic rocks, owing to a preponderance of hard silicate minerals combined with greater uniformity in structure, are more durable than other road-making materials, finer-grained varities offering greater resistance to abrasion than coarse-grained types.

(2) The resistance to wear of igneous and metamorphic rocks, containing an abundance of quartz, hornblende, augite, epidote, and garnet, is greater than that of similar rocks rich in mica, chlorite, serpentine, and calcite.

(3) Foliated metamorphic rocks, owing to the parallel arrangement of their mineral constituents, are, as a rule, deficient in toughness, and, therefore, not well adapted to road construction.

(4) Sedimentary rocks are usually deficient in wearing properties, except in the case of highly indurated sandstones, containing a moderate amount of siliceous clay, cement, and limestones or dolomites rich in quartz and having very little clay.

(5) Rocks for road making break down under impact into fragments, the shape and physical character of which are conditioned by mineral composition and structure.

(6) The effect of weathering is generally to lower the resistance to wear of road materials, owing to the development of soft, in part colloidal, products of alteration. Where the secondary minerals are harder and more crystalline the wearing properties of the rocks are proportionately increased.

(7) The cementing value of road materials is conditioned chiefly by the colloidal products of rock decay and increases in a general way proportionately with these products, reaching a maximum in rocks free from quartz.

(8) The slaking property of rock powders is dependent in the case of siliceous igneous and metamorphic rocks chiefly on the physical character of the primary mineral components, whereas in basic igneous rocks and sandstones it is caused to a large degree by colloidal products of rock decomposition.—*Summary of Bulletin 348 United States Department of Agriculture.*

# The Principles of Crop Production*

## A Review of Early Theories, and Results of Extended Investigations

By Edward John Russell

IN ANY discussion of the principles of crop production it is necessary to begin with the year 1840. By that time it was definitely known that plants consist mainly of organic matter along with a little mineral matter—phosphorus, calcium, potassium, sodium, etc.—to which, however, very little importance was attached. The practical man knew that farmyard manure was the great fertilizer; he also knew that other substances, bones, salt, etc., had, in certain circumstances, considerable fertilizing value. The most obvious facts were the large amount of organic matter in the plant and the large amount of organic matter in the best manures; and it is only natural that chemists and physiologists should have connected these, and argued that the object of the manure was to furnish organic matter for the plant.

By a brilliant stroke Liebig, in 1840, brushed aside this obvious connection and declared that the true function of the manure was to provide, not organic matter, but the mineral constituents which the chemists had ignored. The first step, he said, was to find out what mineral constituents the plant contains, and then to supply these substances in a suitable form. If any one of them is lacking the soil is rendered infertile, and matters will not be put right until that one is added. Thus the whole art of manuring was reduced to an exact science. Liebig was a brilliant writer and secured many disciples. Farmers were told that they need only use a few pounds of simple salts to make their crops grow. It was the first time they had heard the fairy tales of science. We can only faintly realize the utter incredulity with which they received the idea that crops could be raised by small doses of chemicals sold in bags from a factory, in place of the cartloads of farmyard manure that had always been regarded as necessary and sufficient. It was as if farmers had been told that they themselves could dispense with the beef, bread, and beer that Cobbett had said was their divinely prescribed diet, and could live instead on tablets of chemicals.

To make matters worse, the prescription failed in practice, and the downfall of the first manurial principle seemed complete. The Rothamsted experiments showed that Liebig's ash constituents gave little better crops than no manure at all. Liebig had left something out; it was necessary to add nitrogen as well before complete growth could be obtained.

The critics urged that the effects would only be temporary; that in time the land supplied with "artificials" would give out. Experience has shown that this is not so; similarly good results have been obtained at Rothamsted over the long period of more than sixty years.

Part, therefore, of Liebig's principle is perfectly correct: The mineral constituents are indispensable and must be supplied to the plant. The mistake was to suppose that they were sufficient. We may take it as established that crops can be grown satisfactorily and indefinitely by supplying proper quantities of suitable compounds of nitrogen, phosphorus, and potassium. This we can call our first principle. Difficulties arise, however, directly one tries to develop it in practice. Trouble began with the attempts to find out what are suitable quantities to use. Liebig had supposed that the requirements of a crop could be gaged by the composition of the ash. Lawes and Gilbert showed that this was not the case. Thus the ash of the turnip crop contains a considerable amount of potash but only little phosphate; according to Liebig, it should have required mainly a potassic fertilizer. Lawes and Gilbert showed, however, that it required phosphates and not potash, and they concluded that the special requirements of a crop could only be discovered by actual trial.

This view was developed in the sixties in a series of brilliant lectures by Ville. After numerous experiments (he says "many thousands"), he drew up the following list, showing the special need, or, as he called it, "the dominant," for each crop:

VILLE'S LIST OF DOMINANTS.

| | | |
|---|---|---|
| Nitrogen | for | Cereals. |
| Nitrogen | for | Beetroot. |
| Potash | for | Potatoes. |
| Potash | for | Vines. |
| Calcium phosphate | for | Cane-sugar. |
| No dominant | for | Flax. |

In order to ascertain the special needs of the crop on a particular soil, he grew the plants on a series of plots, one of which was given the complete manure, while the others each had one constituent left out. Thus for wheat he obtained the following results, and, therefore, concluded that on this soil wheat requires a good supply of nitrogen, less phosphorus, and still less potassium:

| | Crop per Acre. Bushels. |
|---|---|
| Normal manure | 43 |
| Manure without lime | 41 |
| Manure without potash | 31 |
| Manure without phosphate | 26½ |
| Manure without nitrogen | 14 |
| Soil without manure | 12 |

The method, of course, is perfectly sound, and it has been very widely adopted. It is, however, frankly empirical, and empirical work is never very inspiring, so that for a long time soil work came rather to a standstill.

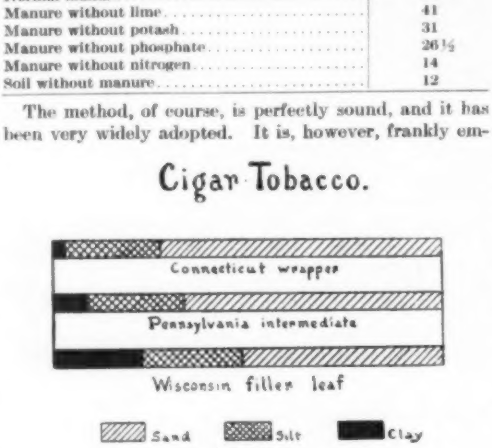



**Fig. 1.**

Showing the relationship between the composition of the soil and the quality of the crop. Soils containing small amounts of clay produced the finest qualities of tobacco ("wrapper" tobacco); as the amount of clay increases, the quality falls off, although the crop becomes larger.

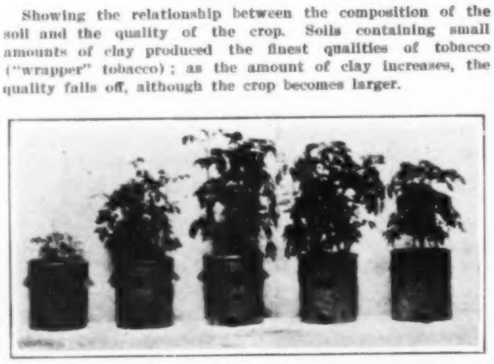


**Fig. 2.—Tomatoes supplied with increasing doses of manure.**

Pot 47, no manure; Pots 55 to 79, increasing dressings of manure. This increases the amount of growth up to pot 72, but it depresses growth in pot 79, where too much is given. The middle pot, 63, is best for fruit.

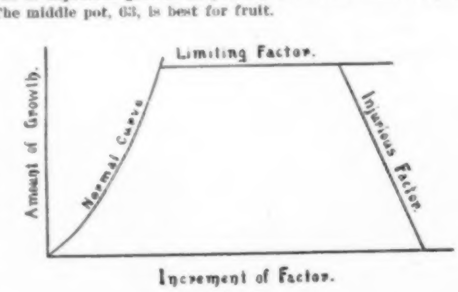



**Fig. 3**

Increases in amounts of the various factors necessary for plant growth do not cause indefinite increases in growth. After a time some other factor becomes insufficient and operates as a limiting factor.

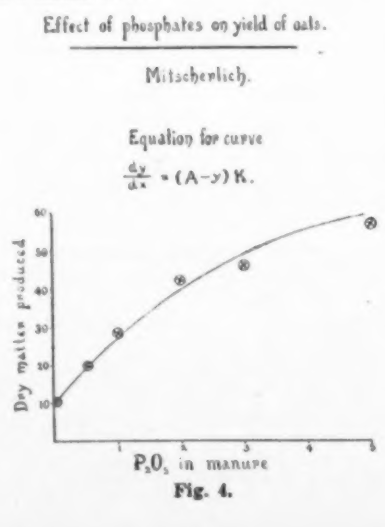



**Fig. 4.**

It has several times happened in the history of agricultural chemistry that the new illuminating idea wanted to revivify the subject at a stagnant period has come in from some outside technical problem that had to be solved. So it was here. The growth of the towns and of stricter ideas on public health had brought into prominence the need for better sewage purification, and it was imperative that the problem should be dealt with somehow or other.

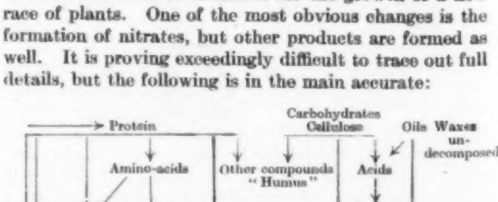
Schloesing and Muntz found that satisfactory purification involved the conversion of ammonia into nitrate, which could be attained by allowing the sewage to trickle very slowly through a tube filled with sand or limestone. There was nothing specially novel in this: the change of ammonia to nitrate in the soil was a well-known phenomenon. It had received a special name, nitrification; some people thought it chemical, others physical, but few troubled themselves about it, and it passed into the category of Things Accepted. The remarkable feature about the investigation of Schloesing and Muntz was the beautiful way in which they developed an observation that most people would have passed over. The conversion of ammonia into nitrate did not set in directly the sewage was allowed to trickle down the column; an interval of twenty days was necessary before it began. Why was this delay? They argued that the process could not be purely chemical or purely physical, otherwise it ought to set in at once. The only explanation seemed to be that it was brought about by living organisms which required time to establish themselves and multiply before setting about their work. If this hypothesis were correct, they argued, the whole process ought to be brought to a standstill by adding a little chloroform—and this was found to be the case. Further, it should start when a little extract of soil was added—this also happened.

This piece of work was brilliantly followed up, and led to most unexpected results. It was seen at once that the soil was not a mere inert mass, but that it was teeming with life and pulsating with change. The number of bacteria is enormous, running into millions per gramme, and the question is raised: How do these organisms live? They must have food, and they must have energy. We are therefore forced to go back to the soil and study it as a medium for the life of a soil population.

A very cursory examination shows that the soil forms only a thin layer; underneath it lies the subsoil, which is wholly different in color, texture, and especially in its behavior toward the plant.

Yet there was not always this difference. When the soil was first laid down it was all like the subsoil, and whenever a new surface becomes exposed, either by landslips, cliff-falls, etc., it is always the subsoil type that appears. The first vegetation has no great supply of plant nutrients, but plants suited to the conditions nevertheless spring up. They take what they can from the crude soil, they take carbon dioxide from the air, they synthesize sugars, starches, cellulose, proteins, etc., deriving the necessary energy from sunlight. When the plants die they fall back on the soil and return to it all that they took, and a good deal more of new material besides. That introduces a fundamental change.

The new material thus added contains stores of energy and food substances suitable for the bacterial population, which forthwith flourishes. Decomposition goes on, nitrates and other substances are produced, and the conditions are made more favorable for the growth of a new race of plants. One of the most obvious changes is the formation of nitrates, but other products are formed as well. It is proving exceedingly difficult to trace out full details, but the following is in the main accurate:




Unfortunately, not much is known about the details, but the reaction is extremely important. The initial products are of little value to the crop or the soil. The final products are invaluable for plant nutrition, and some of the intermediate products are very valuable for

* Lecture delivered before the Chemical Society and reported in the *Journal* of the Society.

the soil. This, therefore, is the reaction on which plant nutrition depends, and it is of the highest importance that it should proceed rapidly and smoothly. Where for any reason it does not, the soil becomes unproductive. This is usually the case on waste lands, commons, heaths, etc. In the Bagshot heaths, for example, there is too little water and too much acid for successful bacterial action, and decomposition does not proceed sufficiently quickly. The land is simple waste and produces no agricultural crops.

Scientific crop production depends largely on controlling this reaction. Three things are necessary: the conditions—the air suply, water, temperature, etc.—must be favorable; the organisms must be of the right kind; and the supply of raw material—plant residues—must be kept up.

We shall see later on how the favorable conditions are obtained. Hitherto little has been done to control the organisms beyond improving the conditions, but beginnings have been made in the direction of inoculation and partial sterilization. The supply of raw material is kept up in several ways; probably the oldest is to leave the ground alone, so that it covers itself with wild vegetation, which is then ploughed in. This formed part of the Mosaic Law;[1] it was the regular mediæval custom in our own country, and it is practised to this day in Connemara. It is too haphazard for modern use, however, and so nowadays the farmer grows a special crop with the express intention of ploughing in all or part of it. Clover, or a mixture of clover and rye grass, is very common, and has the advantage that some can be cut for hay and the rest ploughed in, and the further advantage that the clover plant is associated with one of the nitrogen-fixing organisms.

Other crops instead of clover can be used; for example, mustard, lupines, vetches. A considerable degree of control is obviously possible, because different plants not only yield different amounts or organic matter, but also contain somewhat different compounds.

It is not necessary that the residues should be ploughed in as such. The plants may be fed to animals, and the animal excretions—which represent the parts the animal did not retain or convert into gas—can be ploughed in in the form of farmyard manure.

The second broad principle of crop production is, then, that the biochemical decompositions in the soil must proceed smoothly and rapidly.

New difficulties arise as soon as one begins to develop this principle. Reverting to the diagram shown above, it is seen that the decomposition of proteins may proceed in two ways, either ending with nitrate or with nitrogen. Now the nitrate ending is desirable enough, but the nitrogen ending is highly undesirable. Yet this happens directly the process is speeded up too much. The more intense the cultivation becomes the more serious are these losses; they are bad on the prairies, but still worse under conditions of intense cultivation. To some extent this is inevitable; it is equally true of engines, but just as the engineer has increased the efficiency of engines, so the agricultural chemist has to increase the efficiency of the nitrogen utilization processes.

The difficulty of investigation arises from the fact that these losses, while considerable on an acre of land, are very small in the quantities of soil that one uses in laboratory experiments, only a few cubic centimeters of nitrogen being given off per 100 grammes of soil in a week. The way round a difficulty of this sort is to find a parallel case where the loss of nitrogen is considerably greater, and this is furnished by the manure heap.

Here we are dealing with the same kind of action: the hydrolysis of protein effected by micro-organisms. A very interesting result has been obtained.

After several months' storage under anaerobic conditions the whole of the nitrogen is recovered, although there has been some transformation of protein and amides to ammonia. Directly air is admitted, that is, under aerobic conditions, there is a loss which is apparently not ammonia, and can only be attributed to gaseous nitrogen. Still greater losses set in when we began with anaerobic conditions and follow on with aerobic conditions.

This experiment was done in the laboratory with farmyard manure kept in carefully closed vessels, but we have been able to show that similar results are obtained with soil and also with ordinary manure heaps. Here, therefore, we have reproduced the reaction by which these losses arise. In agricultural practice the losses are aggravated by leaching and become very serious, amounting at the lowest estimate to several million pounds sterling per annum in manure alone, quite apart from the soil. Leaching troubles can be obviated, but this loss by gaseous nitrogen cannot be dealt with until we know just what is happening. The simplest hypothesis is that something formed under anaerobic conditions reacts with something formed under aerobic conditions, giving rise to gaseous nitrogen.

Unfortunately, the purely chemical work on the decomposition of protein has not gone far enough to enable a full working hypothesis to be mapped out. The decomposition does not stop at amino-acids; under bacterial action there is a further change to bases and acids. These are under investigation in several chemical laboratories, but the results have not yet helped us much. Here, therefore, we have an economic problem of the first importance waiting for the solution of a chemical problem which, at first sight, seems rather academic and remote from practice.

These biochemical changes, important as they are in crop production, do not end the matter. The soil comes directly into the reaction; it is not simply the place where the reaction takes place—the beaker, so to speak, where plant nutrients are formed. Some of its mineral constituents come into play. The calcium carbonate neutralizes acids produced during the decomposition. The clay and some of the other constituents possess colloidal properties, so that all these reactions proceed on a jelly-like surface and not in a fluid medium, and they are liable to be affected by all the complications produced by surface actions.

The plant plays an even more active part. Its roots absorb some of the products—the nitrates, the phosphates, etc.—and might therefore be expected to hasten the whole process; but this does not happen. On the contrary, the growing plant appears to retard it, and nitrate is always formed in higher quantities on fallow than on cropped land, even after allowing for what is taken by the crop.

| | In 1911 | | In 1912 | |
|---|---|---|---|---|
| | Fallow land. | Cropped land. | Fallow land. | Cropped land. |
| N as nitrate in top 18" of soil, June ...... | 58·7 | 15·3 | 46·1 | 12·8 |
| Nitrogen in crop .............................. | — | 22·6 | — | 6·1 |
| Total......... | 58·7 | 37·9 | 46·1 | 18·9 |
| Deficit in cropped land ........................ | — | 15·8 | — | 27·2 |

Whether the growing plant affects the nature of the change or only the rate is not yet known. The essential point is that, so far as plant nutrients are concerned, neither the soil nor the plant plays an entirely passive part. The soil is not an inert medium, and the plant is not a mere passive bucket into which the products of the reaction are drawn; each plays an active part, disturbing both the reaction and the distribution of the products.

That leads us to the growing crop. Just as the recognition of the living agencies in the soil altered our whole conception of the soil itself, so the recognition that the plant is a living thing has broadened our conception of the factors necessary for plant growth. In much of the literature of the seventies and eighties it is tacitly assumed that the whole art of crop production is a question of manuring. Agricultural chemists, in short, had got rather into a groove. When this had happened before, they had been jerked out by the necessity of solving a sewage problem. On this occasion the new light came again from the outside, but this time from a study of the quality of American cigars. Whitney was then with the United States Weather Bureau, and naturally came across many instances of the striking effects of climate on both the quality and quantity of crops. It is a commonplace among growers that high quality is often associated with certain climatic conditions. He recognized this, and further observed that in the tobacco-growing States good quality tobacco could be produced on certain soils but not on others, no matter what scheme of manuring was adopted, and he brought this observation into line with his Weather Bureau work by supposing the climate of these soils to be that required for the production of high quality. By "climate of the soil" he meant temperature-moisture content, air supply, etc., and in a very ingenious paper he shows that these factors can be correlated with the size of the soil particles (Fig. 1).

This led to the recognition that the type of the soil is an important factor in crop production, which has had some extremely interesting developments. Mechanical analyses to determine the type became an indispensable part of the routine of soil analysis. The perspective was restored, the fact emphasized that the plant not only wants food, but also proper water supply, air supply, and temperature.

Now there is a very simple rule that applies to all these factors. Plant growth increases with increasing supply of any one of them, but this only happens so long as the supply of every other factor is adequate. When anything is lacking the increase in growth is not kept up, and additional supplies give no extra crop. Finally a stage is reached when extra supplies may do harm, either by direct injury or by cutting out another indispensable substance. This is shown in the tomato experiments of Fig. 2, where successively increasing doses of sodium nitrate are applied in the four pots 55, 63, 72, and 79, although no further growth is obtained in 72 and 79 because of the insufficient water supply. The conditions for favorable growth are all present in pots 72 and 79 excepting only this one, but it effectually prevents the plant from taking full advantage of the good conditions. All this is expressed in a generalized form in the curve of Fig. 3, which thus represents our third principle of crop production. It has only recently been revived in agriculture, although the fundamental idea is old; it can be found in the writings of the political economists of the Malthusian school; it was used in a special form by Liebig in his "Law of the Minimum;" it was developed by Horace Brown and F. F. Blackman. In its full generalized form it is proving extremely useful.

Problems of soil fertility generally have to be approached from this point of view. Whenever a case of infertility has to be studied the first question to settle is: What is the limiting factor? And the next: How

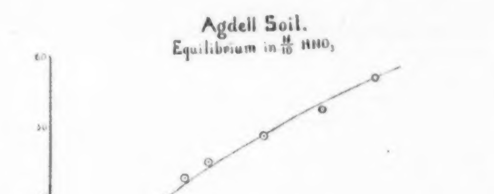



Fig. 5.

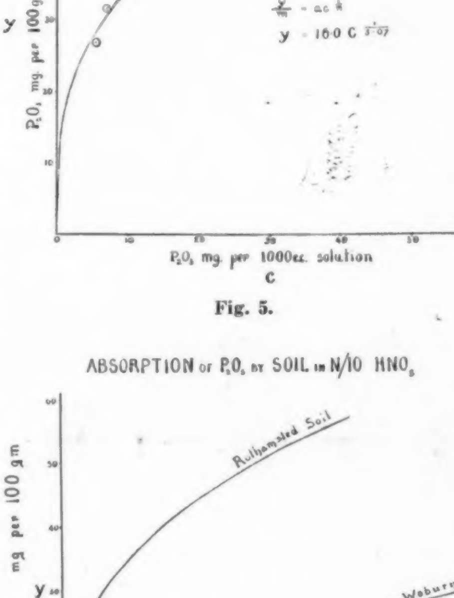



Fig. 6.

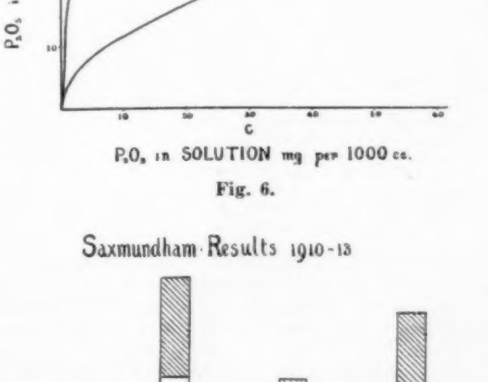



Fig. 7.

Yields obtained at Saxmundham on plots receiving (a) artificial fertilizers alone; (b) artificials and farmyard manure. The effect of withholding phosphates is seen to be far more marked in absence of farmyard manure than where it is added.

[1] Leviticus, xxv., 3-5.—"Six years thou shalt sow the field, and six years thou shalt prune thy vineyard, and gather in the fruit thereof; but in the seventh year . . . thou shalt neither sow thy field, nor prune thy vineyard. That which groweth of its own accord of thy harvest thou shalt not reap . . .: for it is a year of rest unto the land."

can this limiting factor be put out of action? As a rule, the limiting factor is one of the following:

| Limiting factor. | Put out of action by: |
|---|---|
| Wetness | Drainage, liming |
| Dryness | Irrigation, suitable cultivations |
| | Addition of organic matter |
| Lack of temperature | Drainage and cultivation |
| Sourness or acidity | Liming or chalking |

The removal, although simple in principle, may be very difficult in practice: it has often proved to be the rock on which many beautiful schemes for increasing food production have been wrecked. The laboratory experiment may show conclusively that a certain treatment increases plant growth. Every other condition except the one under investigation is eliminated by making it as perfect as can be, and the result may be thoroughly sound from the physiological point of view. It is, however, wholly unjustifiable to assert that such treatment will increase the growth of crops in the field, because one cannot, in the field, eliminate all limiting factors and make every other condition as good as in the laboratory. Even if one succeeds with the soil—which one can very rarely do—there still remains the weather, which may always confound the calculations.

We have seen that, broadly speaking, three general principles of crop production can be laid down:

1. The plant must have a sufficient supply of all necessary nutrients, especially of nitrogen, potassium, and phosphorus.

2. The biochemical decompositions in the soil must proceed smoothly and quickly.

3. All the requirements of the plant must be satisfied. Any one left unsatisfied constitutes a limiting factor preventing further growth. Increases in any one factor give increases in growth until something else proves insufficient and becomes a limiting factor.

No doubt future investigators will find other principles besides these three. It has been suggested that besides the nutrients proper there are certain directive agents akin to the remarkable substances recently investigated by animal physiologists. Armstrong was the first to direct the attention of plant physiologists to the effect of hormones in regulating the vital processes of the plant, and the idea is proving very helpful in forming a mental picture of what goes on during growth. It has aroused considerable interest among agricultural chemists, because it suggests the possibility of increasing the effectiveness of the favorable conditions in the soil. Indeed, quite recently a substance has been produced on the large scale, which claims to owe part of its value to the possession of some such properties. As the matter is still under investigation, I do not propose to discuss it further this evening.

We go back, then, to our three established principles. Each of these can be recognized broadly in every case of crop production, but considerable difficulties arise when one tries to develop any of them; there are so many factors involved and their interaction is so complex. I can best illustrate this by taking one of the factors in some detail, and I will choose one that has received very much attention from chemists, namely, the supply of phosphates.

Phosphates are indispensable for plant growth, and well conducted physiological experiments have shown a simple connection between the amount of phosphate supplied and the amount of growth. Mitscherlich's results are plotted in Fig. 4; the plants were grown in sand, so as to eliminate various disturbing factors. But such simple results are never attained in soil. To begin with, there is always some phosphate already present. At first sight it looks easy enough to take account of this, and simply add it on as a constant in the equation. It has proved almost impossible, however, to give any precise value to the amount of phosphate in the soil that is of any use to the plant. Ville showed years ago that the amounts revealed by chemical analysis are far beyond anything the plant can ever get.

QUANTITIES OF POTASH AND PHOSPHATES IN SOIL AND IN CROPS.

(Ville at Vincennes, 1864.)

| | Pounds per Acre. | | |
|---|---|---|---|
| | In Soil. | In Four Crops of Wheat. | In Three Crops of Beetroot. |
| Phosphoric acid | 1,581 | 62 | 132 |
| Potash | 2,025 | 102 | 288 |
| Lime | 34,674 | ... | ... |

In spite of the large amounts in the soil, the plants began to starve for want of added phosphates, and Ville rather gloomily concluded that "chemistry is powerless to throw light on the chemical properties of the soil." One could hardly expect chemists to acquiesce in that view, nor did they. They faced the situation quite squarely; they had found too much phosphorus and potassium in the soil; they proceeded to try again and find less. Instead of using strong acids they used dilute acids; several were suggested, and by a happy inspiration Bernard Dyer selected 1 per cent citric acid as being the most suitable; although that was twenty-one years ago, 1 per cent citric acid still holds the field in this country.

The part extracted by dilute acids was called the "available" portion to distinguish it from the "unavailable." The new method at once proved very helpful; it was used by Wood in his Norfolk experiments. Difficulties, however, soon began to arise. It was found impossible to assign any definite value to the amount of available phosphate present. Variations in the conditions of the experiment gave wholly different values for the amount of "available" phosphate, while in the case of nitric acid the longer the acid acted the less phosphoric oxide ($P_2O_5$) was extracted.

Now that gave the clue to the problem. It is obvious that there must be two actions going on: a direct solvent action and a reverse action, resulting in the withdrawal from the solution of the dissolved phosphoric oxide. The direct reaction was studied by extracting the soil by a diffusion method; this eliminates the reverse reaction, and the various dilute acids now behave very much alike. The direct solvent action, therefore, is much the same for all dilute acids.

The reverse action was studied by swamping the direct action. Sodium phosphate was added to the soil and the acid was then allowed to act. The whole of the added phosphate was never recovered, in spite of its solubility and the presence of the acid. Some of it was withdrawn from the solution by the soil. By varying the amounts of added phosphate a curve was obtained showing how the phosphate was distributed between the soil and the solution, which turned out to be the ordinary adsorption isotherm, similar in type to that obtained with charcoal and dilute acids (Fig. 5). The constants are not the same for the different acids, and from these curves it is possible to go back and explain the apparently erratic action of the different acids on the soil.

Thus it appears that when phosphate is added to the soil for the purpose of increasing the growth of a crop it does not simply stop in the soil, waiting for the plant to take it up. It reacts with the soil; it is adsorbed, and the amount available for the plant at any time depends on the adsorption relationships. There is, in short, a competition between the plant and the soil for the phosphate. Fig. 6 gives the curves for a clay and sandy soil, which show that adsorption is greater for clay than for sand; in other words, the clay competes for the phosphate more vigorously than does the sand. An amount, therefore, which is sufficient for the plant growing in a sandy soil proves inadequate on a clay soil. This has thrown light on an interesting problem in manuring, for it has long been known that clay soils stood in more need of phosphatic manures than sands. The field results bring out this fact: the yield of barley on the heavy Rothamsted soil falls when phosphates are omitted, but it does not react nearly so quickly on the Wodburn sand.

It seems a far cry from the logarithmic curve expressing an adsorption isotherm to the management of barley and turnips, but the connection is really simple and direct.

This, however, does not settle the matter. The plant is a living thing, and consequently its requirements are not rigidly constant, but vary with the conditions. There are very good grounds for supposing that the plant actually requires more phosphate on a clay soil than on a sand. These are the effects produced by phosphates:

Promotion of early growth,
Promotion of root development,
Promotion of early ripening,
Specially active on clay soils,
Specially in wet regions,
Specially for shallow rooting, and quick growing plants, for example, swedes and turnips.

It is possible that some simple connection underlies all these, but no one has yet discovered it.

Again, seeing that the need varies with the conditions, it is clear that if the conditions are altered the needs may change. When, for instance, a dressing of farmyard manure is applied, some of the properties of the soil are altered; it becomes more porous and more retentive of water, and phosphates may behave differently from what they did before. That is well shown on the Saxmundham plots (Fig. 7).

It is unnecessary to go any further. The point I want to bring out is that the simple and incontrovertible statement that phosphates increase plant growth proves very complex when applied in practice. So it is with the other factors. They can be disentangled and investigated, but it is not yet possible to put them together again and predict the resultant. One cannot set out from first principles and reconstruct the normal case of crop production; the factors are too numerous and too complex.

Yet something has got to be done. The technical chemist has the advantage over his colleague in the purely scientific laboratory that he cannot shelve an inconvenient problem. He is compelled to do something. The practical man brings in his problem with such insistence that, for shame's sake, one is bound to make an endeavor to solve it. A method has been evolved, an empirical method, which, while not very rigid, has at least the merit that it works. It consists in going into the field and finding out the actual agricultural properties of the soil by observations, inquiries, and direct field experiments; these have to be repeated for two or three years because the first results may only have been a trick of the weather, but if the same result is obtained for several seasons running, one may be sure of being right.

All that is old; it is, of course, Ville's method over again. The new part consists in trying to extend the results to other soils. For this purpose a soil survey of the area, usually the county, is arranged. The surveyor goes over the ground with a geological and orographical map and divides it up into areas of similar soil and vegetation characteristics. He then takes samples of soil typical of each area and makes fairly complete chemical, physical, and bacteriological studies of them. Simultaneously he collects information from the farmer about their agricultural properties, and, if necessary, arranges for proper field trials.

In this way a collection is made on the one hand of the agricultural properties, on the other of the chemical, bacteriological, and physical data, of typical soils. It is obvious that the possession of these standard soils helps the analyst and expert adviser very considerably; if a farmer asks for information it is much easier and safer to compare his soil with the standard than to attempt any absolute measurements. Moreover, these soil surveys are greatly facilitating advisory and analytical work.

They do far more than that, however. The normal case of crop production can never be decided on purely laboratory methods because there are always two or three varying factors, whereas in the ideal laboratory experiment there is only one factor varying. We are not, however, confined to the ordinary laboratory methods. Statisticians have to deal with problems involving two or three variables, and they have worked out a method—the method of correlation—which, when intelligently applied, gives valuable results. It is hoped to apply this to crop production. The necessary masses of data are slowly being accumulated, and it is anticipated that very interesting results will be obtained.

The ordinary laboratory method, however—the one factor method—may still on occasions work satisfactorily. It sometimes happens in nature that one of the various interacting factors overshadows all the rest and virtually eliminates them, so that here too it is possible to apply laboratory methods with satisfactory results.

For example, on a certain type of clay soil the whole situation is controlled by the circumstance that phosphates are almost absent, while the need of the plant for phosphates is particularly great. The addition of basic slag in these circumstances has caused most remarkable improvement.

Another illustration is furnished by our work on the partial sterilization of soils. We had several times had occasion to carry out the fundamental experiment showing that the decompositions cease once the soil has been heated sufficiently to kill all organisms. On one occasion, however, the autoclave was out of order, and the soil was only heated sufficiently to kill the active forms and not the spores. To our surprise, the bacterial activity was now much greater than before. Other methods of partial sterilization had the same effect. These results are reflected in plant growth, which is markedly increased by partial sterilization. Other experiments, which I need not now describe, showed that any treatment of the soil which is detrimental to life produces the same effect, sometimes, of course, with secondary effects as well. Conversely, it was shown that any method of treatment favorable to life, such as increased temperature and moisture content and addition of stable manure, leads, sooner or later, to a falling off of bacterial activity. The simplest explanation of the phenomena is that the soil population can roughly be divided into two groups: one favorable to the production of plant food, the other not. The useful population is, on the whole, more resistant to adverse circumstances than the harmful organisms, and therefore survives more drastic treatment. Hence any method that kills some, but not all, of the soil population effects an improvement and leads to good results. A continued spell of favorable conditions, however, enables the harmful organisms to establish some sort of superiority. This hypothesis throws important light on the behavior of the soil in natural conditions, and it reveals another factor in crop production. We have not yet succeeded in making much of it in the normal case; indeed, we have hardly attempted to do so, for the reason I have already given; there are so many interacting factors. There are, however, cases where this one factor largely dominates the situation. In glasshouses run at a high pitch, where the soil temperature and water content are high, and where large dressings of organic manures are used, the bacterial efficiency falls off so much that the plants begin to suffer. The soil, in the picturesque language of the practical man, is said to become "sick." This sickness proved so difficult to deal with in practice that the problem was given up; the soil wa thrown out and new soil brought in to take its place.

As soon as the problem came to our notice it was easy to suggest a remedy. The reduction of bacterial activity seemed clearly due to an excessive development of the detrimental organisms. It was only necessary to adopt partial sterilization to get rid of these and to give the useful organisms a better chance of action. The basis of a suitable method was already in existence; steam had been used to kill insect pests in the houses, and by suitable modification this process was successfully used for the treatment of sick soils.

In cases of this sort, where only one factor is concerned, one is back to the old laboratory conditions in which one was brought up and trained to think, and consequently there is always considerable hope of success. It is fortunate for us that these cases puzzle the practical man more than the normal case, so that he rather tends to bring them in as specially difficult problems, and any little success on our part brings us more credit than we really deserve.

There is, however, a very real advantage. The most fruitful ideas for working out the development of our subject have often been got from abnormal cases brought in by the growers. Practical men have the great advantage that they are compelled to keep their eyes open for Nature's problems; they cannot shirk them, or they find their crops suffering and themselves losing money. The close association of Science with an industry is, therefore, a great advantage, because it brings in new problems which, if properly investigated, may prove extremely valuable in opening up new fields of knowledge. There is an exhilarating freshness about all this work that one often misses in the more academic investigations.

All the same, while speaking in praise of applied science, one must recognize that science cannot be applied until it is developed. We have seen, and instances might have been multiplied, how the hydrolysis of protein throws light on the proper management of a manure heap, and how the adsorption isotherm worked out for charcoal and dilute acids clears up a difficulty in the manuring of turnips. It is impossible to set any limit to the value of good work in science honestly carried out. The fact is that Science and Creative Industry are one and indivisible, and any attempt to divorce them may only end in disaster.

# Color-Vision—I*

## And Color-Vision Theories, Including the Theory of Vision

By F. W. Edridge-Green, M.D., F.R.C.S.

Twenty-five years ago I pointed out in minute detail how defective the wool test for color-blindness was. A special committee of the Royal Society was appointed to decide on the truth of my statements, but though it took my evidence it refused to examine my cases, and decided in favor of the efficiency of the wool test. A departmental committee appointed a few years ago to decide the same question, took my evidence at length, but, as before, would not let me demonstrate facts and cases to it, even though I made a strong protest against this course. The Board of Trade did not adopt my lantern (the official test of the navy) but constructed a lantern similar to one of my discarded models, and it will be interesting to note the results of the examinations with this lantern compared with those of a specially improved wool test, in which five test colors are employed, two of which are similar to those recommended by me twenty-five years ago if a wool test were to be employed. It will be seen that 52 per cent of those finally rejected passed this improved wool test, while not a single person other than normal sighted was rejected by the wool test alone. It should be noted that a present examiner, and member of the committee, stated, in a book issued after the report, that the wool test was sufficiently good! This attitude, which is unfortunately so common, especially at Cambridge, of expressing a strong opinion while refusing to look at the facts, is not only unscientific, but absolutely dishonest, and brings discredit not only on the academic individual who evolves his science from his inner consciousness, but upon the real scientific worker who does his work with the most punctilious and conscientious accuracy.

It is necessary to make these few preliminary statements, because authority appears to paralyze the reasoning powers of nearly every one, and it will be, therefore, necessary for the reader to think for himself in perusing this article.

The theory of vision and color vision which I adopted as a working hypothesis is as follows:

A ray of light impinging on the retina liberates the visual purple from the rods, and a photograph is formed. The rods are concerned only with the formation and distribution of the visual purple, not with the conveyance of light impulses to the brain. The ends of the cones are stimulated through the photo-chemical decomposition of the visual purple by light, and a visual impulse is set up which is conveyed through the optic-nerve fibers to the brain. The character of the stimulus and impulse differs according to the wave-length of the light causing it. In the impulse itself, we have the physiological basis of the sensation of light, and in the quality of impulse the physiological basis of the sensation of color. The impulse being conveyed along the optic-nerve to the brain, stimulates the visual center, causing a sensation of light, and then, passing on to the color-perceiving center, causes a sensation of color. But though the impulses vary in character, according to the wave-length of the light causing them, the retino-cerebral apparatus is not able to distinguish between the character of adjacent stimuli, not being sufficiently developed for the purpose. At most, seven distinct colors are seen, while others see, in proportion to the development of their color-perceiving centers only six, five, four, three, two, or none. This causes color-blindness, the person seeing only two or three colors instead of the normal six, putting colors together as alike which are seen by the normal-sighted to be different. In the degree of color-blindness just preceding total, only the colors at the extremes of the spectrum are recognized as different, the remainder of the spectrum appearing gray.

It is obvious that this theory could not be true if the facts of color vision were as stated in the books of twenty-five years ago. Apart from the relative functions of the rods and cones, if color vision were a secondarily developed power of discrimination, then the following should be facts:

1. There should be innumerable varieties of color discrimination, which could be arranged in a series from total color-blindness to super-normal color vision.

2. The number of colors seen in the spectrum should depend upon the development of color discrimination; those colors presenting the greatest physiological difference being the first to be discriminated.

3. The physiological difference would probably correspond roughly to the physical difference; that is to say, the largest and smallest waves would be the first to be differentiated.

4. Yellow should be a simple but secondary sensation.

5. A pure spectrum should be divisible into a series of monochromatic areas, the size of these areas depending upon the development of color discrimination.

6. There should be defects of light perception distinct from defects of color perception; shortening of the red or violet end of the spectrum should be distinct defects, and not necessarily associated with defective color discrimination.

7. There should be innumerable varieties of dichromic vision.

8. There should be trichromic cases of defective color perception, three colors being seen in the bright spectrum, yellow being seen as red-green, and blue as green-violet.

9. All colors when reduced sufficiently in luminosity and area should appear white, the color disappearing first in the least developed portions of the retina.

10. Simultaneous and successive contrast should be increased in those with defective color discrimination.

11. Those with defective color discrimination should see like those with better discrimination in conditions of more difficulty.

Now all these predictions have been fulfilled, and are found to be actual facts, so that while the facts support the theory, they present difficulties to be solved by any other theory.

We will now review a number of facts of color vision in order to show the requirements of any color-vision theory. Further details will be found in the papers to which references are given.

### I.—The Facts of Color Mixing.

The fact that any color may be matched by a combination of three selected spectral colors is the foundation of the trichromatic theory which was propounded in order to explain it. The trichromatic theory which may be represented by $\alpha x + \beta y + \gamma z =$ any color, is only one possible explanation of the facts. Let us take, for instance, the fact that when spectral red and spectral green are mixed in appropriate proportions they match spectral yellow. The other explanations of this fact are that red and green each contain a yellow element, when the two are mixed the red and green cancel each other, and only the yellow is left (Hering): that the yellow was the original substance, and has become split up in the course of development into a red and a green substance, and when green and red are mixed they combine into the original substance yellow (Ladd Franklin): that in previous stages of development all men saw the yellow region as red-green, but when a new color yellow had replaced the red-green of a previous stage of development a mixture of red and green gave rise to the color yellow which had replaced the red-green of the previous stage (Edridge-Green). Now it will be noticed that these three last hypotheses all explain the facts better than the trichromatic theory, which does not, like the others, explain why red and green should make yellow and not red-green, especially in view of the fact that it does make red-green to some persons. Many physicists confuse the mixing of objective lights with the mixing of physiological sensations. This particularly applies to those who state that the trichromatic theory is not a theory, but a fact; not only is it not a fact, but only a possible explanation of certain facts, and, as will be shown in the remainder of this article, there is not a single fact which directly supports it, but very many which show that it cannot be true. Those writers who state that three-color photography or three-color printing are based on the trichromatic theory ought to state that they are based on the facts of color mixing. In the case of mixing pigments the primary colors are different, certain yellow and blue pigments when mixed make green instead of white, which is the case when pure spectral light is used. The reason of this can be made plain by examining a yellow and a blue glass with a spectroscope: it will be noticed that the yellow lets through orange and green as well as yellow rays and the blue lets through green and violet as well as blue rays If the two glasses be super-imposed, and then placed before the spectroscope, it will be noticed that only the green rays get through, the others being stopped by the combination of the two glasses.

### II.—The Simple Character of the Yellow Sensation.

If the trichromatic theory were a fact, it should be possible to show that the sensation excited by pure spectral yellow is a composite sensation, and there should be evidence of its alleged components. Every fact, however, shows that yellow is a simple and non-composite sensation. If the eye be fatigued with pure yellow spectral light the spectrum will appear to have lost its yellow, and though yellowish red or yellowish green will appear less yellow, the terminal red of the spectrum will not be affected. If the terminal portion of the red end of the spectrum be isolated in my spectrometer, it will appear as a faint red upon a black background. If the eye be fatigued with red light, even by looking through a red glass held against a light for one second the red will not be visible for some considerable time, but the eye may be fatigued for twenty minutes with yellow light without interfering with the visibility of the red light.

It is known that if the intensity of a number of colored lights be reduced in the same proportion all the colors do not disappear at the same moment. If, therefore, spectral yellow were a compound sensation, it should change color on being reduced in intensity. If, however, spectral yellow be isolated in my spectrometer, and the intensity be gradually reduced by moving the source of light away, the yellow becomes whiter and whiter until it becomes colorless, but does not change in hue.

The eye may be fatigued with red or green without altering the hue of spectral yellow. Spectacles glazed with red or green glass of a kind which is permeable to the yellow rays may be worn for a considerable time without altering the appearance of spectral yellow. If yellow were a compound sensation a wearer of red spectacles should see the yellow through them as green, because the yellow would fall on a portion of the retina which had been fatigued for red.

### III.—The Facts of Color-Blindness.

Cases of color-blindness may be divided into two classes, which are quite separate and distinct from each other, though both may be present in the same person. In the first class there is light as well as color loss. In the second class the perception of light is the same as the normal-sighted, but there is a defect in the perception of color. In the first class certain rays are either not perceived at all or very imperfectly. Color-blind individuals belonging to the second class can be arranged in a series. At one end of the series are the normal-sighted, and at the other the totally color-blind. I have classified the color-blind in accordance with the number of primary colors which they see in the spectrum. If the normal-sighted be designated hexachromic, those who see five colors may be called pentachromic; those who see four, tetrachromic; those who see three, trichromic; those who see two, dichromic; and the total-

* *Science Progress.*

ly color-blind. There are many degrees included in the dichromic class. There may or may not be a neutral band, and this is widest in those cases approaching most nearly to total blindness.

The fact of this gradation of color perception has now been definitely recognized. The old classification of red-blindness, green-blindness, etc., has no meaning—experts examining the same case may diagnose it differently. The late Dr. Pole, who was color-blind (a simple dichromic), was examined by Maxwell, who stated that he was completely red-blind, and subsequently examined by Holmgren, who pronounced him to be completely green-blind! Shortening of the red or violet end of the spectrum is a distinct defect from defective color discrimination. A normal-sighted person when examined with my spectrometer with a bright spectrum marks out about eighteen monochromatic divisions, those with defective color discrimination mark out a fewer number in proportion to their defect. The dichromic see two colors in the spectrum, red and violet, with a neutral division of varying size between the two colors. The trichromatic see three colors in the bright spectrum, red, green, and violet. The orange and yellow regions are seen as red-green and the blue region as green-violet. Here we have persons who have three sensations who are to a certain extent color-blind. Sir William Ramsay and Sir J. J. Thomson belong to this class. A trichromic in conditions of difficulty becomes dichromic. As the colors are farther apart in the color-blind, simultaneous contrast is increased.

IV.—THE EVOLUTION OF THE COLOR SENSE.

It is obvious that the sense of light must have been developed first, and then the sense of color. Let us consider the evolution of the color sense in accordance with the difference of wave-length. First there will be a colorless spectrum, then a spectrum with a tinge of red at one end and a tinge of violet at the other, then the red and violet will encroach on the white region until they meet in the center, and a fresh color green is developed. In further development the red-green region is replaced by yellow, the blue replaces the violet-green region, then orange becomes distinguishable, and finally indigo. Every fact points to this being how the evolution of the color sense has taken place, and there are various degrees of color perception corresponding to every stage in the process.

V.—NORMAL COLOR VISION.

The theory of color discrimination given accounts for the facts of normal color perception. When a spectral light is diminished in intensity colors disappear in the order of their development. Complementary colors are a necessity of the theory. In the dichromic red and violet are complementary to each other, and a mixture of red and violet is confused with white and green. When the stage is reached that green is distinguished as a separate color, vision assumes the trichromic character which henceforth remains, and green now becomes complementary to the other two colors.

VI.—SIMULTANEOUS COLOR CONTRAST.

1. The colors seen by simultaneous contrast are due to the exaggerated percepton of a real objective relative difference which exists in the light reflected from the two adjacent surfaces.

2. A certain difference of wave-length is necessary before simultaneous contrast produces any effect. This varies with different colors.

3. A change of intensity of the light of one color may make evident a difference which is not perceptible when both colors are of the same luminosity.

4. Simultaneous contrast may cause the appearance of a color which is not perceptible without comparison.

5. Both colors may be affected by simultaneous contrast, each color appearing as if moved farther from the other in the spectral range.

6. Only one color may be affected by simultaneous contrast, as when a color of low saturation is compared with white.

7. When a false estimation of the saturation or hue of a color has been made, the contrast color is considered in relation to this false estimation. That is to say, the missing (or added) color is deducted from (or added to) both.

8. A complementary contrast color does not appear in the absence of objective light of that color.

9. The negative after-images of contrasted colors are complementary to the colors seen.

VII.—COLOR ADAPTATION.

Color adaptation is the term applied to the changes that take place when the eye is subjected to light in which certain wave-lengths predominate. Color adaptation is the means by which colors appear to remain the same when the physical conditions are quite different. Daylight differs chiefly from the Osram electric light in that it contains many more blue rays and less red. A piece of bright blue paper appears a darker blue by an Osram light than by daylight. The fact that it appears blue at all is due to color adaptation, for if we place the blue paper in a photometer and illuminate it by Osram light it will be matched exactly by a piece of chocolate-brown paper illuminated by day-light. It will be noticed that the theory of perception of relative difference accounts for all the facts. The following are the facts of color adaptation:

1. In color adaptation, the retino-cerebral apparatus appears to become less and less sensitive to the color corresponding to the dominant wave-length, and to set up a new system of differentiation.

2. When light of a composition differing from that of day-light is employed to illuminate objects, an immediate and unconscious estimation of the colors of these objects is made in relation to this light, the light employed being considered as white light.

3. No color is seen of which the physical basis is not present in the light employed.

4. When spectral regions are examined with a color-adapted eye that of the dominant wave-length appears colorless while those immediately on either side of it appear to be shifted higher and lower in the scale respectively.

5. There is immediate color adaptation, as well as color adaptation after a longer stimulation with the adapting light.

6. Colors which correspond to the dominant wave-length of an artificial light are with difficulty discriminated from white by this light.

7. Color adaptation may bring two colors below the threshold of discrimination so that the two appear exactly alike, although by another kind of light a difference is plainly visible.

8. Color adaptation increases the perception of relative difference for colors other than the dominant.

9. The conscious judgment has very little effect in color adaptation.

10. Color adaptation greatly helps in the correct discrimination of colors, and masks the effects of the very great physical differences which are found in different kinds of illumination.

11. Spectral yellow, after color adaptation to green, still appears yellow and not red.

12. Color adaptation appears to produce its effects by subtraction of the dominant color sensation, and not by directly increasing the complementary. Spectral blue does not appear brighter after color adaptation to yellow.

VIII.—AFTER IMAGES.

As in all experiments with color pure spectral light must be employed. If a monochromatic region be isolated in my spectrometer a negative after-image can be produced by looking at this fixedly with one eye for twenty seconds. If the eyes be kept in a vertical position, that is, one over the other, then, on the eyes resuming their normal position, the after-image can be projected upon the middle of a horizontal spectrum thrown upon a screen. As the eye is kept rigidly fixed during the fatiguing process a very clear-cut negative after-image is produced which, when thrown on the screen spectrum, enables close comparison to be made with adjacent parts. The stability of the after-image is remarkable; it does not change color, and is not in-influenced by subsequent light falling on the retina when this is not of too great intensity. The after-image is in every case darker than any dark object on which it is projected.

If the portion of brain having the function of the perception of color be continually receiving impulses which, affecting it and the visual center, cause the sensation of light which is seen in the absence of all light stimulation, and the whole retino-cerebral apparatus be fatigued by light of a certain wave-length, a negative after-image will appear through simultaneous contrast. If one portion of the visual area be less sensitive for impulses caused by light of a certain wave-length (for instance red), and the adjoining areas be stimulated by impulses corresponding to light of all wave-lengths, the image corresponding to the fatigued area will be relatively blue-green to the images corresponding to surrounding areas. This explanation on the theory of color vision given is in accordance with the other facts of simultaneous contrast.

It is impossible to explain the facts of negative after-images and successive contrast on the Hering and Young-Helmholtz theories of color vision.

The complementary to the exciting light is never strengthened in the spectrum on the screen by the after-image as it should be according to the Hering theory. When a negative after-image has been formed in an absolutely dark room it becomes increasingly difficult to produce this after-image on the second, third, fourth and subsequent attempts. The opposite should be the result on the Hering theory. The stability of the after-image is remarkable, it does not change color or oscillate, and is not surrounded by the primary color as it should be according to this theory.

The effect of fatiguing the eye with a monochromatic region produces a union gray band across this region. On the Young-Helmholtz theory this should vary in color luminosity across its breadth.

On this theory the after-image should change color on fading, because of the varying amount of fatigue of the hypothetical color sensations. This is not the case. Regions like violet after fatigue to red should be very little affected, but they are the most affected. The fatiguing light should chiefly affect the region used for the fatigue. This is not the case. An after-image should not be seen in the absense of all external light.

*(To be continued.)*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